

THE HUMAN FACTOR
IN WORKS MANAGEMENT

THE HUMAN FACTOR IN WORKS MANAGEMENT

BY
JAMES HARTNESS, M.E. (Hon. University, Vt.)
MEMBER AMERICAN SOCIETY MECHANICAL ENGINEERS
INSTITUTION OF MECHANICAL ENGINEERS
FELLOW AMERICAN ASSOCIATION
ADVANCEMENT OF
SCIENCE, ETC.

FIRST EDITION
THIRD IMPRESSION—CORRECTED

McGRAW-HILL BOOK COMPANY, INC.
239 WEST 39TH STREET, NEW YORK
6 BOUVERIE STREET, LONDON, E.C.
1912

Copyright, 1912, BY JAMES HARTNESS

THE · PLIMPTON · PRESS · NORWOOD · MASS · U · S · A

FOREWORD

This book is an attempt to set forth some of the most essential principles of industrial economics. Special emphasis is laid on the proper use of the human being, especially as regards modes of employment of mind and body.

Particular attention is given to those modes of use that are the most favorable to the comfort and success, not only of the man in the office or works, but to the success of the organization, or industry, or nation. Emphasis is also given to the value of habit, both as a present means and as one by which progress can most easily be made.

In reaching the conclusion of any book touching subjects so varied as this, there is a feeling of the incompleteness of the treatment.

This must always be so.

We can do no more than contribute our mite,

and it is better to make our contribution now than to wait till a larger sum is in hand.

There may seem to be a lamentable lack of direct examples which might illustrate the application of the theory, doctrine, or law set forth; but since such examples will readily come to mind to any one who has caught the spirit of the book, this lack may not be really objectionable.

The main purpose has been to build up a standard of measure by which all ideas for management may be measured: one that will measure an ordinary suggestion for change that may come up during the day, or one that serves equally well in determining the real character of some of the greater policies or systems of management. In other words, the purpose has been to contribute more to a true poise of mind than to add one jot or tittle to the excellent schemes of management that may be set forth in other works

CONTENTS

FOREWORD	v
--------------------	---

PART I

CHAPTER I

THE VALUE OF HABIT	3
------------------------------	---

Success Depends More on the Man than the Plan — Systems are a Means, not the End Sought — Progress from Invention — Selling the Product — Habit — New Habits Can be Established — Organization Efficiency — Objections to Specialization — Value of Habit in the Industries — Following the Habit Grooves — Human Inertia — Human Welfare and Industrial Success — Building on Habit — Unfavorable Conditions Must be Changed — Different Kinds of Men — Fitting the Pegs to the Holes — Specialization — Misuse of Energy when Specialization is not Practised — Mind and Body must both be Considered — Dissipation of Energies.

CHAPTER II

THE INERTIA OF HABIT	43
--------------------------------	----

Giving Inertia Its Proper Value — Building on Old Ideas and Habits — Control of Progressive Energy — Considering the Individual — A Tired Body Dulls the Brain — Division of Work — Working in Strange Surroundings.

CHAPTER III

THE DIFFERENT VIEWS OF INDUSTRIAL ORGANIZATION	58
The Manager's View — The Value of a Market — Improvements often Bring Trouble — Progress must Continue — Capacity for New Ideas — Money not the Only Dividend.	

CHAPTER IV

INCREASING THE ASSIMILATING CAPACITY	70
Selection of Equipment — Labor Cost not the Only Consideration — Output per Dollar Invested — Fundamental Principles.	

PART II

CHAPTER V

SOME NON-TECHNICAL PHASES OF MACHINE DESIGN	81
Natural Fitness — Repeated Thinking — Con- centrating Attention — Interest must be Awak- ened, not Forced — Establishing Useful Ruts — Problems to Consider — Designing by the Square Foot — Invention should not Mix with Detail — The Hero of the Evaser — The Toughened Idealist — Conforming to Economic Conditions — Get- ting Back to Nature — Technical View Insufficient — Easiest Way to Improve — Avoid Obscure Parts — Getting Out of the Rut — The True Value of a Business — Physical Condition of Worker — All Men are Human Beings — Controlling the Mind — Coöperation Necessary for Success.	

PART III

CHAPTER VI

MACHINE BUILDING FOR PROFIT 119

Good Results with Moderate Effort — Unimportant Details — Seeing One Thing at a Time — The Spell of Environment — Financial Hazard — Conditions that Effect the Hazard — Value of Specialization — Ambition Mania — Lack of Confidence in Product — Confidence in Existing Things — The Workers Help Bring Success — Progress with Full Knowledge of Facts — Largest Profit per Dollar Invested — Cost of the Product — Tying up Capital in Stock in Process of Construction.

PART I
THE VALUE OF HABIT

THE HUMAN FACTOR IN WORKS MANAGEMENT

I

THE VALUE OF HABIT

THE value of habit is understood when we realize that it is the way by which man thinks and acts most efficiently.

This kind of habit is usually designated as the usual custom, mode, or practice. It is the product of repetition of either a mental process or an act, or both. There may be either a complete or partial independence or interaction of the mind and body in the acquisition of habit.

The ideal and most progressive process of habit-building starts from a mental stimulus. But a very efficient habit condition may be established by mere repetition such as is frequently enforced by environment in the business or manufacturing world. Under such conditions even a certain kind of mental habit may be built up by routine clerical

4 HUMAN FACTOR IN WORKS MANAGEMENT

work in which the man has little or no interest.

These conditions do not awaken that interested attention that is so essential to the higher type of mental processes, but they actually form a very efficient habit, and it operates without serious hindrance to the wandering of the thoughts to other subjects.

As a classical example of this kind of functioning of mind and body we may cite Thomas Edison's account, in his biography, of the telegraphers at Nashville receiving their first intimation of the assassination of President Lincoln from the cries of the newsboys in the street, notwithstanding that the message had been transmitted to the local paper through that office.

The whole subject is not exhaustively treated, only a line of thought being presented with the hope that this principle of the force of habit and its real economic value may be given a more careful consideration in all plans for betterment, progress, and profit.

Habit seems to be the missing link that is needed to connect some of the present systems of management to the industrial world as it is.

SUBDIVISION OF WORK OR SPECIALIZATION

The whole treatment is in harmony with this idea, and to this end it emphasizes the importance of specialization. It is hoped too that it clearly demonstrates that economic success is dependent on the most complete subdivision of work and the greatest number of repetitions of thought and action by each individual up to the extent of his mental and bodily comfort. The extent of comfortable repetition varies greatly in different people. It is at its lowest ebb in the Jack of all trades and in the restless, rapid thinker. Its highest development is found in nearly all who have contributed notably to the progress of the world. It may be strengthened or lessened by popular opinion or by environment, but it is finally the gauge to which the number of repetitions should go.

Repetition forms habit and is absolutely necessary for success in this world today. It will be even more so in the future, for a shiftless wandering of the mind or body should never be tolerated. While repetition work has been condemned by many, it is not in itself

6 HUMAN FACTOR IN WORKS MANAGEMENT

degrading. On the contrary, it is the best means for developing concentration.

This in the business man, inventor, or works manager, calls for continuity of thought along a given line. It will not tolerate a wandering mind, no matter how strenuous it may be, working by the desultory process. It says that men shall not be mental tramps, but that they shall keep their thoughts on their home work. In the factory it demands that every man's mind and body should have the most efficient use.

The most complete subdivision of work must be made, to the end that each division may be readily understood, and that in this division and classification of tasks there may be a place for every man, and that every man should be in his own place.

REPETITION NEED NOT BE DEGRADING

This is not a doctrine that degrades. It is one that simplifies the processes within the reach of the greatest number, and by repetition of operations each man may easily become most efficient at his particular work. And last but not least, it clearly demonstrates

the inexorable law of the ultimate supremacy of the largest organization in a given industry, and in turn of the commercial or industrial supremacy of a state or nation that favors and fosters such organizations. It is not necessary for the organizations that specialize to have special trade relations. It is only necessary for them to carry to the most complete subdivision all of the various mental and physical tasks in order to obtain the great results that accrue from repetition of processes.

There is a way under some conditions of work to get this advantage of repetition of processes in comparatively small organizations. But whether the organization is small or large, the economic advantages go to the one in which each operation has the most favorable number of repetitions by the individual.

Mere size of an organization, then, does not give it strength. A large organization may be very weak if each officer and workman is required to know about and perform a great variety of operations. But such dissipation is fast passing out of practice. The large organizations are specializing, and in so far as they do this they will succeed.

8 HUMAN FACTOR IN WORKS MANAGEMENT

Under the heading of "Some Non-Technical Phases of Machine Design" will be found an effort to show the most efficient uses of an inventor's or designer's energies, by indicating what should be considered as essentials in machine design, and how an inventor should work. Although this title implies an application to a restricted field of industry, it is of far wider application, the concrete examples only furnishing a means of illustration.

It is given in its original form as a lecture delivered before the Stevens Engineering Society, composed of students of the Stevens Institute of Technology. It is hoped that it will be of value not only to the machine designer and inventor, but to those who have to direct or coöperate with them.

SUCCESS DEPENDS MORE ON THE MAN THAN THE PLAN

In the industrial world we are confronted by the instability of things. There is a fluctuation in the fortune of each industry, each organization and, unfortunately, of each mortal. We know of no plan that can infallibly control either the ebb or flow of fortune.

There are men who have been uniformly successful in all of the undertakings in which they have engaged, but whether they can give to others their plan or not, we know that they never do. It is doubtful if any complete scheme can be formulated, the variants and the combinations are so new and so numerous.

Perhaps we should not insist on the explorer telling us how he got there. His business is to get there. He may have taken instructions from some one who never did and never could get there, or he may have made his own plan, but in either case his success was doubtless due to the way he carried out the plan. In other words, his success was the outcome of either his own methods or his own interpretation of another's scheme, so that there is no prospect of our being able to sail by rule. The industrial sea is not fully charted. There is still a need for the navigator to sail "guess and lead" and "luck and log." The hardest workers and the most strenuous thinkers seem to be as unfortunate as those who take life less seriously.

But, while these facts are true, it is not unreasonable to believe that we are truly

progressing toward a better control of the economic condition. For, great as has been the increase in intricacy of business relations and the complication of mechanical devices, there has also been a marked advance along lines of analysis of economic elements, with a tabulation and deduction that have brought much of the industrial problems within the reach of the ordinary mind. This advance has not been made any too soon. In fact, it has been tardy in arriving, but it is now here and it is now being carried forward by some of the best industrialists in the land.

SYSTEMS ARE A MEANS, NOT THE END SOUGHT

It must not be thought, however, that analysis, tabulation, and simple deduction are the beginning and end of industrial science. They are only the scheme for coördinating the various forces. This process is so purely statistical that it must not be mistaken for a major means. It is rather a minor means for coördinating the principal means. It tends to give a wholesome counterbalance for an over-visionary scheme of management, but in its function of coördinating all other forces, it

must itself be subjected to whatever modification is necessary to make it fit into and use the real forces.

In trying to solve the problems we naturally turn to observing all kinds of organizations. We find that they all bear evidence of imperfection. Even the most successful are seldom found to be wholly free from economic blemishes.

There may be either an indifference to the appeals of the advocate of this or that system of betterment, or a tendency to follow some one branch of improvement with more or less neglect of other opportunities. The neglect is not due to an actual undervaluation of the importance of the other elements, but because the enthusiasm over one element robs the others of the force that is necessary to carry them forward.

The mere mental acceptance of the true valuation of each of the other elements does not bring any real valuable help. The enthusiastic push of some one mortal is necessary back of each scheme of betterment.

This should be facilitated by a subdivision of the duties of management. The head con-

12 HUMAN FACTOR IN WORKS MANAGEMENT

trol, however, should try to keep a general view of the whole and see to it that there is a harmonious pull of all of these forces.

Just now we have many who have taken strong interest in the "Scientific Management." This system improves the efficiency of an organization by giving to each worker a thorough direction for the performance of his duties. Among other features it keeps an accurate record of the time required to perform each operation, and uses this as a basis to estimating time required to perform other similar or nearly similar operations. It is a methodical scheme of intelligent direction of work, and it depends for its success more on correct direction of operation than on the workman's natural ability and inclination to devise his own methods.

This is not set forth as an accurate statement of the "Scientific Management," but it is in brief an impression that has been gained by observation and study of this most valuable plan. The system doubtless is intended to include the use of every means for progress, but in practice it seems to lay emphasis on the best use of the present means, rather than the invention of new and wonderful machin-

ery. "The best use of the present means" is a policy that should be given first place in all schemes of industrial management. It is the most economically sound principle that can be set forth. It meets the present needs. It is not a barrier to progress by invention, and if intelligently carried forward it need not run violently against the force of habit of the workers.

If the present use is not as efficient as it should be, the "Scientific Management" plan provides for a direction of the workers along other modes of use. It usually makes slight changes in the means, but it gains its greatest results by giving the workers instructions that help them to make more efficient use of their energies and the present means. The reason that it has not had more universal success is doubtless due to the inertia of habit of both the workers and the management, and it is to this phase that the present discussion aims to direct attention.

PROGRESS FROM INVENTION

Before taking up this phase of the question, let us briefly glance at some of the other forces which we must consider.

14 HUMAN FACTOR IN WORKS MANAGEMENT

One of the other forces that makes for the more efficient use of capital and labor is that which aims to improve the means.

This is strongly contended for by the inventor, and when it is considered wholly by itself it is one of the most fascinating of all schemes. It seems from the inventor's and promoter's standpoint to be the only royal road to success for it does not depend on increasing the physical effort of the man.

Surely we know that it has a host of advocates. Nearly every industrialist is ready to use a new invention that is offered for the purpose of reducing cost of production or increasing the quality of output. So fascinating is this phase that it has led more than one over-enterprising management to misfortune.

We know that it is a force that has been most potent in progress, and in some respects must still be given a most careful consideration in connection with any plan of management, but yet it is not the only one of the elements to be considered.

SELLING THE PRODUCT

Among other schemes for industrial success may be included all that affect the sale or

demand for the product of the plant. An enthusiastic commercial spirit is by some considered a most vital element. From the commercial standpoint the market requirements and demands must be met. These are so important and so complicated that it is difficult for one whose mind is filled with them to clearly see the economic conditions of the manufacturing side of the business.

For instance, the great need of ultra-specialization does not seem apparent, and sometimes the force of inertia of habit in the works is underrated. The problems of business-getting are so involved that there is no chance to clearly see the importance of the purely manufacturing need.

The many other forces that affect the success will readily come to mind, although they will differ slightly in the various organizations and industries.

One more force is the momentum of practice, or inertia of habit or custom, or just plain "habit." And this is to be the central theme of this discussion. All of the forces must be considered, and the policy adopted must be a rational coördination of them all,

but they seem to focus on the force of habit, which is too often overlooked.

HABIT

The sense in which the word "habit" is used in the present discussion means the condition of body or mind, or both, which has been established by repetition of an act or mental process, or both. It may be strengthened or weakened by persistent purpose, but nevertheless mostly depends for its strength on the frequency and number of repetitions.

Its importance in the industrial world is that it is the condition of mind and body by which a man acts with greatest precision, ease, comfort, and efficiency. It is a condition that must not be carelessly disturbed, for there is found to be a deep-rooted antipathy to abrupt change.

Skill, dexterity, facility in performance of work is due to acquired habit. This is also true of all kinds of work in the business office and the workshop. This fact alone shows the value of habit in an industrial organization, especially when we realize that habit is a disposition as well as an aptitude to do

work. The practice brings an involuntary tendency to continue, and with it an ease and reliability of performance.

The mental habits are special qualities that have been acquired by the same process of repetition. The successful man in the commercial world, the inventor's domain, the financier's realm, or any other branch of mental work, is one who has acquired habit of thought along lines of special value in his own particular field. There are undoubtedly men born to each of these callings who would be unable to qualify for any other, but these cases are so rare that for our present discussion they may be disregarded.

NEW HABITS CAN BE ESTABLISHED

There are also those who during the early and most impressionable years have been subjected to an environment that has established habits of thought or action of a kind unfavorable to the existence of a more desirable kind.

Both of these kinds are somewhat handicapped in trying to take on other kinds of habit of mind or body, but since habit may be

built up by mere repetition, there is a chance to make over many of these men.

In case of a man having a disliking for the only work at which he can obtain a livelihood, whether it is due to inborn traits or traits acquired from environment, it is a long, hard fight. But continued practise will win, and in many of these cases it will even drag the mind along to a less antagonistic attitude.

The ideal and easiest way to acquire habits of industry is to have the mind lead off in desiring such work. Although either process makes for skill and other evidences of habit, the quickest, easiest way, the one that attains the highest efficiency, is one that is acquired by an eager, earnest, persistent mind which maintains an interest and concentration of attention to the subject.

It is not within our present scope to go back to the most impressionable age of child or man, for that should antedate the time of his entering the industrial world, but this habit problem cannot be understood without due allowance for the condition in which men are found in the industries. This includes, as stated, the inborn characteristics and those that have

been acquired, especially from environment, during the impressionable years.

After passing the most impressionable stage, man acquires his habits of work almost wholly under force of circumstances. Generally, however, his work habits never become of great strength if he has previously acquired a group of habits of mind and body that combat the acquisition of habits of work.

That this may become merely a habit of action is not denied, but that it may, under favorable conditions, become a powerful enemy to the adverse mental habit must also be admitted. It is this condition on which we must depend and build if we are to obtain success in the industrial world.

ORGANIZATION EFFICIENCY

Efficiency of the organization as a whole depends on the coördination of its various elements, and since the men in the organization constitute the most important part of all its elements, we must see to it that there is the most perfect coördination of their movements.

When a man is on entirely new work and is not acting along habit lines, there is no pos-

sible way of determining in advance *how* or *when* his task will be accomplished. Hence there is no possibility of coördinating his work with the work of others. But when all are following a fixed routine, the coördination becomes possible, and then we actually have an organization working on habit lines, built, of course, on the habit processes of the individual men in that organization.

Since efficiency depends on strength of habit, we are led to selecting methods that tend toward the greatest habit building and strengthening processes. This, like every other road of investigation of the elements that affect industrial success, leads us directly to the choice of policy that favors the most complete subdivision of operations. This subdivision must be carried as far as possible, so as to give each worker the advantage of the skill and the efficiency of action that is only to be acquired by repetition. It also leads us to specialization which concentrates the largest possible organization to the smallest possible range of work.

The ultimate supremacy of an organization managed by this policy is assured, not merely because it limits the field of endeavor of each

worker, but because it also limits the range of duties of each officer. This results ultimately in each one becoming highly efficient and well informed in that part of the work. The "all-round man" cannot successfully compete with the specialist.

OBJECTIONS TO SPECIALIZATION

The objections to the scheme of ultra-specialization are usually born of anxiety over the unfitness of a specialist for other work and his great handicap in finding work in times of depression or general industrial disorganization. This argument against specialization is equally potent for the individual and the industrial plant, and it frequently deters the management from transforming their establishment into one devoted to a limited range of work. To wave it aside as irrelevant would be unwise, but to let it hinder us from traveling the road that offers greatest opportunities would be a serious mistake.

VALUE OF HABIT IN THE INDUSTRIES

At the present time there seems to be no chance of success on other avenues. The

22 HUMAN FACTOR IN WORKS MANAGEMENT

assurance, the ability, the absolute control of the situation, comes only to the man or corporation or nation that is strongly fortified by useful habits.

The power of habit in the industries is one of the most clearly demonstrated facts in this world. Its value there in solving problems has been proven many times, and yet it is almost wholly ignored by many of our most energetic disciples in the Efficiency crusade. The only men who make a stand for the value of habit are men who are considered non-progressive. Since they belong mostly to the silent majority, their views should be most carefully considered.

Most of us who have given careful thought to these problems have felt that almost any method of work may be changed over completely by an appeal to the intellectual side of men. And we are well warranted in this opinion. But there is reason to believe that we have frequently underestimated the force of the intelligent energy that must be expended to offset the current of habit or custom.

It is a mere physical task to change the course of a river, but to change the habit of

thought and action requires a long time and the use of the subtlest agencies. We can introduce new methods of conducting business and of manufacture, but in doing so we must keep in mind the force of habit of thought and action of the mortal man, as he is found in the directors' room and in the various positions throughout the plant.

So deeply grooved are these habit ruts that a letter written in business seldom contains evidence of real fresh thought on the subject. Each letter is made up of phrases that have been uttered a thousand times, and each statement made is the product of thought of other days. It is the result of the writer's mental attitude, which in turn is the product of his past experience. One letter of fresh matter written each month requires more energy than a month's output of two or three hundred per day of the routine type.

FOLLOWING THE HABIT GROOVES

When real new matter is put into letters or into operations, it is at the cost of either mental energy or cash, or both, and if one new letter is written without expenditure of

mental energy, it is very sure to involve cost in cash later.

It is the same, only to a greater degree, in the various operations through a manufacturing plant. Each workman as well as each officer follows naturally and most comfortably in a habit groove of both thought and action.

If this statement seems to imply that a change is to be advised, then the text has been misleading, for no such purpose has been intended. On the contrary, the condition set forth is the natural one, and it is the one that should be followed, if an economic success is to be attained. Of course, something will be said later about schemes of progress which may be carried forward, but these schemes must all conform to nature as it is seen in the real life of the industrial world. They must not be the product of abnormally optimistic mortals who fail to recognize the normal condition under which the real normal man works.

This should not antagonize the man that wants every mortal to have a joy in his work that comes from use of the brain. There is to be no scheme set forth that will hinder the brain-work, but it will minimize the stultify-

ing effect of inefficient use of brain. The new work, the new thought, the improvement in methods and the invention of new means should all go forward, but in conformity with natural law. The joy in the work should not involve financial disaster for a nation, an industry, or a workman. That would be the joy of a fool's paradise. The joy of the work should be had in taking progressive steps in natural ways.

When a business is conducted or work done contrary to this principle, it goes contrary to nature, and it is generally unprofitable and unsatisfactory to the investor, to the officers, to the workman, and to the users of the product.

HUMAN INERTIA

If we wish to arrest a large fly-wheel which is running at a high speed, we know that we may shut off the motive power and then carefully apply a brake or some other form of resistance. We know that an instantaneous stopping of its motion is impossible, and that shorter methods invite disaster. A fast moving express-train cannot be arrested instantly, and it is equally impossible to instantly

get the same train from a standstill to full speed.

In industries we have frequently seen the evidence of inertia when an attempt is made to change over the method of work. This inertia that resists our efforts to change the velocity of a moving object, or to move an object that is in the state of rest, is usually considered as a property of the purely physical matter and not wholly applicable to living creatures.

The principle as it applies to an inanimate mass can be readily demonstrated anywhere and any time, and that the proof is always quickly given and in a way that is seldom subject to misinterpretation. But, while the case is not so obvious in its application to industrial work, its effect cannot be doubted by any one who takes a bird's-eye view of the various workings in this industrial world. The evidence of the effect of inertia of the mind and habits of the human being, taken singly or in groups, is just as surely written in the records of industry as any fact in physics if we look at the matter clearly.

HUMAN WELFARE AND INDUSTRIAL SUCCESS

The plan that gains the greatest real benefit for each mortal is the one that in turn brings the greatest success to each industry and nation, and, if it is universally applied, to the world in general.

The line of action should be one that takes into consideration the inertia of the human being, as to habit of both thought and action. There should be a constant effort to improve conditions, but the progressive work should be prosecuted in keeping with the laws of inertia.

It should be an effort of the intelligent kind, — one that takes into consideration that all men are not equally sensitive to suggestion, — that all men are not born to rule or to dream of lofty schemes. It should recognize that some are happiest with a wholesome kind of work, work that gives their bodies the needed exercise and is sufficiently fatiguing to bring on a desire to go home and get the pleasure of rest; that some are happier at clerical work; that others find their greatest pleasure in the skilful control of a machine or instrument,

while still others gain most in the study of intricate mechanism.

All of these should be equally considered. And last but not least, the greatest thought should be given for the man who does not spend much time in trying to solve all the problems, but who, nevertheless, is the most important element to consider on account of his representing the greatest number of men. He is the one for whom the thinkers should think, and when they think for him they should not think that he thinks as they think. He does not think that way at all. His view is from another standpoint. It may be a truer view of the real world; surely it is the one held by the greatest number.

The welfare of all men, from the Napoleons of industry to the newest recruit into the work, should be so considered that each man should have the best work for which his endowment and general characteristics fit him.

We lift up a man when we take a worker whose greatest achievement has been to inefficiently handle a shovel and by patience teach him to do a better work; one by which he creates more value,—and one in which he can

obtain a better wage for himself and family. If his brain is not made to guide a nation, this work may not be so degrading as it may seem. The work for each should be the highest type available for him. One of the greatest crimes against this or any other mortal is to make him discontented with his natural place in this world.

BUILDING ON HABIT

The natural and most efficient scheme of conducting business is to build on habit. We see evidences of this on every hand. The specialist is superior to the Jack of all trades. This fact has been known for centuries, but never before have conditions existed which have so forcefully demonstrated it. It applies to the business and commercial side of the industries as much as it does to the manufacturing side.

The skill of the workman is due to his continual application to his own particular work. A lathe hand cannot turn out his best day's work without his own lathe and his own tools, his own bench and work and general surroundings. Give him another lathe of even the same

"make," and it may be days before he attains his previous record. Change his work frequently, and you have reduced his output.

This condition goes through all kinds of work in manufactory and office.

There are two general objections to the ultra-specialization plan. One is wholly commercial and the other is wholly humanitarian.

They are both fundamentally wrong. The commercial view seems to show that specialization involves a high cost of selling, and that it is impossible to obtain a sufficient volume of one kind of work to make it practicable, and the humanitarian thinks that it degrades the worker to restrict the range of his operations.

Neither of these views takes in the whole subject, and either one may lead to an erroneous conclusion.

We will devote most of our space to discuss the practical and economic side of the question. But since the mind naturally shrinks from any conclusion that is not humanitarian, let us first clear away the fallacy that specialization in itself is degrading to the workers.

PLACE FOR EVERY MAN, EVERY MAN IN HIS PLACE

Specialization seems to be the line along which we have made our progress. And yet we sometimes feel that it must be against the welfare of the race when we see unfortunate cases of misplaced men, men who are tied by circumstances to work that seems to hold them down to a lower standard than their natural one. But these cases of misfits are not representative of the vast majority. The majority of men in the industrial world are in vastly better positions than were their ancestors.

UNFAVORABLE CONDITIONS MUST BE CHANGED

We know that hard physical labor does not produce the clearest mentality; that over-strenuous manual effort seems to lower the perceptive powers; that even monotonous light work is a real drudgery, whether it is the use of a pen or of light instruments, and that all such work may be detrimental to the mind, either by hindering its development or by actually dampening its ambition. Furthermore, nerve-racking environment may be detrimental to both mind and body.

These and many other conditions exist and are most unfortunate, but there has never been a time when there was less of the adverse conditions, and it is probable that the natural evolution of things will reduce many of these. These conditions are not necessarily an accompaniment of specialization. They are only the temporary maladjustment that has always gone along with human progress.

There is a way to greatly minimize these unfortunate conditions that is not against the interest of the business or the individuals in it. And this is the only way that we should take. It only involves the use of our brains in seeing to it that each man's work in the world is the best that is available for him. And when he is in that position, see to it that he is given every facility for improvement of which he is capable.

In order to make this clearer, let us see what are the principal elements in this problem.

DIFFERENT KINDS OF MEN

We know there are all kinds of minds and all kinds of bodies. Some need plenty of exercise: others are most efficient and nearest

normal when leading a very quiet life. The man who from a lofty position in this world feels a desire to lift up every one into a more strenuous life is like the boy who gave his grandmother a trumpet and drum for a Christmas present. He thinks others want what he wants, but this is not the case.

There are men who lead the happiest lives in other ways. Their natural work — the work in which they most efficiently use their energies and in which they get the best development of mind and body — may not be in scrambling after some world-recognized laurel, or even laboring to impress their neighbors of their great importance on earth. Their lives are best lived in their natural pursuit of comfortable existence.

There are many men on earth who do not want their brains racked with perplexing problems; men who are willing and glad to do any work that is wholesome, providing they can get a good livelihood; men whose minds are not idle, even when doing the so-called monotonous work.

There are others who, though qualified for higher positions, are perforce of circumstances

34 HUMAN FACTOR IN WORKS MANAGEMENT

loyally performing their duties in order to keep a necessary income; men who, even under such circumstances, are using their surplus mental energy in the better performance of the duties of their work and in study, work, or pleasure out of work hours.

In many cases the position toward which an extra ambition might push them would render them, by its exaction of strenuous work and worry, wholly unfit to lead a comfortable existence. Many a worker who at some time has had responsibilities thrust upon him knows that the real "peace of mind that is dearer than all" takes flight when the burden of responsibility is taken on. Such workers have found that study at home in the evening is not to be enjoyed by a man who comes home with brain already tired out by duties of the day.

Such contentment is not understood by one who is built by nature to thrive in an environment of responsibility. He thinks this contented fellow-man is lazy. He does not know that there is little or no laziness in this world of the kind that that term usually implies.

Both the so-called lazy and energetic are alike following nature's law. The former may need an extra stimulation or force of circumstances to induce him to take the amount of work and exercise that is best for his mind and body, while the over-energetic man may require a treatment of an extremely different kind in order to hold him down to the greatest performance of which he is capable without loss of mental poise. Both extremes are on the earth, and there should be a way by which each might be placed where his peculiar characteristics will render the best results to himself.

FITTING THE PEGS TO THE HOLES

In the industrial world all kinds of mortals should find their natural places. And with the natural evolution which will doubtless soon force the human mind to take up this problem of proper position for each mortal, there will be a great improvement in the conditions of the worker in the industrial establishment. But it is needless to hope to attain anything like contentment and comfort as long as there is an irrational raving about the debasing

effect of industrial work. The most ordinary operations may be performed by men who are not qualified to do better work and who without this work would be idle.

In the same way, all of the various positions in an industrial establishment should be filled. In each position there should be a man who is in the best place in the world, for him.

This digression is not long enough to fully state the case, but it is hoped that with what follows it will serve to allay any anxiety regarding the welfare of the worker in the industry which tends toward the economic state of specialization.

SPECIALIZATION

Specialization divides the work into various classes so as to have all of one kind of operations performed in one place. It tends to reduce the range of operations performed by each man. For instance, when a man's work is limited to watching a tack-making machine, we find that his mind and body fit into the conditions. This soon results in a more perfect comprehension of the intricate mechanism of

the machine and in acquiring a wonderful skill in making the necessary adjustments. He then becomes most efficient in producing a large output of tacks. He does this work easily; in fact, it is safe to say that efficiency and comfort go together.

This same man would be a very unsatisfactory workman if required to change from one kind of machine to another every day, with no chance of running the same kind twice in a lifetime.

To those who have seen and perhaps felt the joy that comes to a worker as he invades new fields or encounters new problems in his own field, there is something repugnant about the scheme of specialization which limits each mortal to the work in which he has acquired skill and in which his mind and body seem to act automatically.

There may be pleasure in rambling through the world of work, but it is too much like the pleasure that comes from dreaming or building of air-castles. It is a misuse of our powers. It gives a peculiar pleasure to some beings, particularly those who have exceptionally

38 HUMAN FACTOR IN WORKS MANAGEMENT

active minds, but these same mortals would better serve themselves and their families by a more efficient scheme.

MISUSE OF ENERGY WHEN SPECIALIZATION IS NOT PRACTISED

In such dissipation of energies there has been wasted something that is of greatest value. The individual has had the pleasure of working very hard, but at the end of the week or year or life it is clearly apparent that the plan of work has been faulty. It has gone contrary to the most efficient scheme, and the awakening from the dream has not been pleasant.

We do a great wrong to men when we direct or restrict them to performing their work inefficiently. Congenial labor is, we know, one of the greatest blessings in this world. It is a greater blessing to the worker than to any one else, but it should be rightly directed by those in positions to direct. If energy is allowed to be expended in effort that goes contrary to all natural laws there is an irreparable loss to the world, to the industry, and to the man. The drone is of more use to the world than the man who misdirects labor.

Specialization, when it works as it should, takes into consideration not only man's efficiency when acting along lines of habit, but it gives every aid to making the methods fit the requirements of mind and body. The mind requires food for thought along the best line of which it is capable of thinking. It should make a constant effort to fully comprehend the work, with a view of fitting for progress to the next better position, or if that is wholly distasteful or hopeless, then it should have some wholesome line of agreeable thought.

MIND AND BODY MUST BOTH BE CONSIDERED

The mind should not be allowed to wander, for wander it will if it is not directed. It should be furnished with some interest, either in the form of study that is taken up out of working hours, and which can be permitted to occupy the mind while work of the habit kind is being done, or, if it is not a study, there should be some wholesome interest or pleasure.

Music to some furnishes this need. Music heard in the home or elsewhere will sometimes occupy the mind during working hours when

the work is of a monotonous character. In some instances music has been provided during a certain part of the day, just for this need of workers who are employed in an occupation that in itself furnishes no mental nourishment. Readers are also employed in some places for the same purpose.

But these extreme cases do not represent the vast majority. They apply only to the needs of the mind of those engaged in a work in which they can awaken no interest. Nearly all kinds of work offer a chance for the average man to get interested directly in the work itself. Such an interest soon bears fruit in the results as well as in the comfort of the worker, and it is this phase on which we must depend for making specialization comfortable and profitable to the worker. It is this phase that is wholly overlooked by those mentioned above who have seen or felt the joy of work that comes to one who rambles into a new field. They fail to see that the same kind of mental pleasure may be obtained while working along the natural and efficient lines of habit, and that in one case they have had pleasure at great expense of wasted energy, and in the other

case they may have made a true progress for themselves and others by moving along the natural way.

DISSIPATION OF ENERGIES

This tendency to dissipate energies by wandering into other fields is not confined to the worker; it is a most common tendency of business men. A manager of an industrial establishment has to continually combat his tendency to divert the energies of the organization along new lines. He knows from past experience how dearly bought is each new method that is introduced into his organization. He knows, for example, that it would make all of his men tardy at the plant in the morning if at the hour of arising he has issued a request for each man to dress by carefully thinking out each move. He knows that the day's work would never be well done if he asked each one to think before acting.

Even conversation comes under the law of habit. It must follow the line that has been carefully thought out.

We all know that when a man talks on subjects with which he is not familiar, his words carry very little weight.

The so-called spontaneous utterances that seem so full of life and are apparently the product of a flashed thought, are either the welling up of some subconscious ideas quickly reconstructed to fit the situation or they are a haphazard jumble either meaningless or conveying an unintended impression. They are generally in the humorous line, and frequently make an impression that was not anticipated by the utterer.

The really useful talk and work is the result of wholesome habit of thought and action.

II

THE INERTIA OF HABIT

THE application of a policy of management based on the efficiency of habit is comparatively easy. In fact, it may seem to be too easy to be progressive.

There is no fact in nature that is more readily demonstrated than the inertia of habit. This inertia, which constitutes a positive resistance to a quick change may, when properly used, serve to accomplish the greatest results.

If inertia alone has full sway, there is no chance for change, but we know that there are many other elements to consider.

In the affairs of mortals we have been giving too great weight to the importance of other influences. This is partly due to our false idea of the grandeur of man's estate.

It will not lessen this grandeur to own up to some of our limitations. On the contrary, there is reason to believe that if we are truly great we will not only admit the facts, but we will use the data to plot out the best course

to pursue, and then we will actually travel along that course.

GIVING INERTIA ITS PROPER VALUE

The important point for us to decide is the value to give this element of inertia, when we are deciding policies of management of affairs that come under our control. In all teaching, from the kindergarten up, we take full cognizance of this principle of inertia. In engineering we bow low to it. In fact, we actually bow low to it in all things, although at times it is more in defeat than in gracious courtesy.

There is in some men a constant desire to advance by attaining greater skill, knowledge, and efficiency. This desire becomes a strong purpose, and it may change the course of the mortal, just as the attraction of the sun or of some other body may cause the planet to deviate from the straight course. We know that these other influences are very potent in controlling affairs in this world. In fact, they are so potent that they have been given the whole credit or blame for the resulting condition.

It is our present purpose to show that inertia has the greatest control under the circumstances

of every-day life, and that the effect of other conditions is comparatively small.

There may be instances of the boy at the plow quitting the work in the middle of the furrow to take up a great life work. We know of men changing from bad to good habits, and unfortunately from good to bad, almost instantly. We know that great changes in processes of manufacturing have been successfully made within a very short time, but all these examples are comparatively rare, and every one of them, if analyzed thoroughly, will show that an immense bottled energy of strong purpose was released to produce the change.

Such cases when viewed with our human eyes seem to be the normal and only natural way to progress. Surely, great advances effected by revolutions in social, political, and other habits of thought have on the surface appeared to be the result of a quick change due to the master-mind or wilful purpose of man.

But the efficient use of this valuable energy is more desirable. It should be used in conformity with nature's laws, just the same as we propose to use the energies of those who are not goaded on by some great purpose.

BUILDING ON OLD IDEAS AND HABITS

In considering ways and means for efficient management of industrial organizations, it is not necessary to commence at the beginning of each plant. The method of dealing with the problems of existing plants is also applicable to new organizations, for a new organization is only *new* in a limited sense. It uses men of experience. It uses existing machines and implements. It follows existing methods of conducting business and in the general management of its affairs.

Even the so-called new method which may be the center around which the so-called new business is built contains very little that is new. The newest things in the ordinary industrial world contain many old and well-known elements. The very use of a so-called new method or machine as a center around which to build an organization is in itself so old that it is a confirmed habit with us to be lured on to investing in such things by the statement that some new process or means is to be employed.

A really new thing that calls for wholly

new ways and new means for manufacture is almost inconceivable. The nearer we approach to newness in the industrial world the thinner becomes the ice on which we are moving. Therefore, let us know that when we advise following habit lines in all moves in management of an existing organization we imply that the same course should be taken in establishing a new company or organization.

In both cases we should employ existing ways and means, experienced men, and well-tried implements. Both old and new should be conducted along the usual line in conformity with the state of the art, the habits of the workers, and other conditions indigenous to the locality. Any scheme of going contrary to the existing customs and usage must be entered into with full knowledge of the great need of patience, force, and courage to offset the barrier of inertia.

CONTROL OF PROGRESSIVE ENERGY

Progressive energy is so valuable that it needs no rating at this time. We have had its value stated so often that it is actually over-rated in the average mind. Not that it has

been overvalued, but that the reiteration has obscured the importance of other qualities. There should be a greater appreciation of the value of energies that are wholly employed in accomplishing results by old means and methods.

Progressive energy, when it is kept within certain bounds, is a prime asset of an industrial organization. It is like a wholesome amount of labor to man; it may be drawn upon without loss, and its use actually strengthens its source. But when it is not wisely kept in control it only annoys and interferes with real progress and real accomplishment of results.

The only way to get work done is to let the worker move along habit lines. The only way to progress efficiently is to make the new ways and means lead off gradually from those in use.

The progressive man who actually directs work along such lines is the most valuable to the world. The one who ignores the "moment of inertia" is a disturber, whether he is a director or a "hewer of wood and carrier of water."

The man who is doing the real work in the world is not the so-called progressive. He is one who points out newer or better methods which may be easily established by a gradual exchange of old habits for new ones.

The conservative may at times seem to have a real aversion to change of any kind, and the reason of this aversion may be found by a little thoughtful study of the psychology of the case. If we do not get it by study, just let us go back in our own memory and think of some time when we have been burdened down with either strenuous physical strain or a combination of mental and physical burden, or just plain worry. And, while trudging along under this burden, think of the time when a most excellent mortal, with good intentions but little knowledge of the real way to help another, came forth and told us our method of working was absolutely wrong, and how he then started in to tell us, by short or long drawn out impartial talk, just what we ought to do.

If our memory records that we smiled sweetly and graciously thanked our reformer, it is evidence that our memory is either one of the most desirable kind, or that we were at

that time and are probably still the most wonderful of mortals. It is more probable, however, that we were not in the mood to receive the choice bits of knowledge, and if we made reply it did not reflect our best selves.

A thousand examples might be given, but one more may suffice.

CONSIDERING THE INDIVIDUAL

Foremen and others who have direct charge of workers know that even the best-natured man should not be directed contrary to his habit method when he is under stress. In fact, it is not well to try any new thought on a physically tired man. This same worker, under conditions of rested mind and body, might be a so-called progressive.

Suppose we take two men exactly alike in all respects, with exactly the same knowledge of work to be done, and let them together undertake to dig a ditch, or repair or adjust an intricate machine, or any other kind of work. Let one of the men get in an awkward position to shovel earth or pull a wrench and become a trifle fatigued either by the physical strain or

the worry of the work, and let the other take a less strenuous part in the undertaking. We will then find that one has been changed into a progressive and the other into a conservative. The one who is tired from the strenuous part of the work cannot see why the other should suggest digging around a boulder instead of lifting it out of the ditch bodily, or why it may not be necessary to dismantle the whole machine in order to discover the fault. He cannot tolerate any suggestion of a new method of working. It is actually easier for him to do the work by the more laborious but "habit" method.

Remember both of these men were the same in every respect, both energetic and neither one lazy (if, indeed, there is such a thing, but that is another story). Remember, too, that we can change them from day to day, putting first one and then the other in the physically strenuous position, and as often as we have changed their positions we have changed their point of view and they become alternately progressive and conservative.

The brain of the man shoveling in the ditch does not work as well as his brother's standing

on the bank. The worker does not want to be disturbed. You hurt him if you insist on his working his brain while his body is under stress. And this is one of the fundamental points for the director of work to take into consideration.

A TIRED BODY DULLS THE BRAIN

It is not necessary to assume that the worker has an inferior brain, and in fact we should not do so. It is only necessary to know that you must not try to extract a full measure of energy from the mind when you are already taking it from the body.

I am well aware that there is a possibility of developing both mind and body, and that some well-informed men think that the condition mentioned obtains only when there is an excess of stress of manual or mental labor. I have no intention to discuss the fine points of the question. I am only stating facts that have been observed thousands of times, when there has not been a severe burden of either kind of work.

This fact will show us that it is not natural for the worker to be interested in the pro-

gressive schemes for betterment of methods of work or management of business. That his most natural attitude is antagonistic to anything that is unwisely and thoughtlessly sprung on him, and that this attitude is not necessarily due to his mental or physical make-up. It would be there just the same if all men were made exactly alike in all respects. It is the result of the work he is doing.

Bearing this state of affairs in mind, it behooves the progressive man to approach the problem of applying his theories in a very careful manner. He must realize that the men in various parts of the work are under stress of every day's requirements that makes it very difficult to intelligently take up any new scheme of procedure. Many an ideal doctrine is a beautiful thing in theory, but of little value if its introduction requires an immense but unavailable energy to put it into practise.

He must realize that it is the doing of work that counts and that the men who are doing things must not be annoyed. All plans for betterment must conform to the assimilating power of the men and must not cut off their

food in time of change. In other words, the new plans should be so matched on to the old methods that the change to the new will not interrupt the production.

We have seen that the most efficient way to use man's energies is to allow him to follow habit lines of thought and action, and that the highest efficiency is reached when these habits are habits of concentration of attention and are restricted to the smallest variety of work.

The wandering habits, whether of the dreamer, the tramp, or the Jack of all trades, are not of the efficient kind. Concentration of attention to a given subject brings its reward, if the subject is not too ponderous for the brain to weigh.

THE DIVISION OF WORK

The division of work into separate operations makes it possible to divide the subject into relatively small sub-problems. This division of the subject itself brings it within the capacity of lesser brains and makes it very much easier for a brain of greater power. In other words, the subdivision of work makes

places in which all mental equipments may be used.

It is of no benefit to any one to keep the problems difficult by making each man think out a process for accomplishing each one of a great variety of operations, when the work may be so divided that it is only necessary for him to think of just one little part of the whole. And we should not befog the issue by saying that this is degrading.

Some of the greatest scientists that the world has known have concentrated attention to the smallest conceivable part of this world, pieces so small that the microscope alone revealed them to the eye. There is a chance for a thinking mind in most of these places that have grown out of this process of finest subdivision of work. *The hardship comes only when the mind cannot get interested in the work.* In many cases this is undoubtedly due to a misfit, but in most cases it seems to be due to a false notion that there is nothing there of interest.

The subdivision of work must go on. If hindered in any one plant or industry or nation more than in others, the result will be a loss.

to that one, and on the other hand, the one that carries it to the most efficient point will become the most powerful.

This subdivision develops greatest dexterity and skill, as well as the keenest comprehension of the ways and means of attaining a given end. And this dexterity of operation is more easily carried on than is the fumbling uncertainty of the work of the more primitive type.

WORKING IN STRANGE SURROUNDINGS

For example, we may take the inefficiency of a plumber in a strange house. So inefficient is his work under such conditions that we charge it all up to laziness or wilful disposition to run up a big expense. But, as a matter of fact, plumbers are actually human beings, made of the same clay out of which has also been modeled the more highly efficient worker and thinker in other fields. The real difference is that he is called upon to work in all kinds of places, no two of them alike, and no two problems exactly the same. He must think and work under the most unsuitable conditions. His work gives us an extreme example

of the way in which all of the mechanical operations were originally carried on, and we can see clearly that it is very inefficient.

We should not lessen the weight of this example by introduction of the statement that the plumber is seldom under the direct supervision of a foreman or some one who knows how the work should be done. For even this phase, when carefully considered, is found to also indicate that the subdivision gets its greatest results from the better supervision made possible by the subdivision, not only of the work of the workers, but the work of the directors of the work.

In the case of the plumber, a very wise man indeed is needed to give him instructions about how his work should be done in a strange place. It is exceedingly difficult to direct work even in a factory, if each workman must do a variety of kinds of work. Therefore, it will be seen that the subdivision of work operates favorably in control and direction of work as well as in the execution.

III

THE DIFFERENT VIEWS OF INDUSTRIAL ORGANIZATION

WE will next consider the views of various members of an industrial organization. No two of the members will be found who have exactly the same viewpoint. The inventor, the business man, the financier, the works manager, and others, all have their own viewpoint and the resulting mental attitude.

Let us begin with the inventor's viewpoint.

The inventor, from his point of view, sees the great need and opportunity to improve the design of the machine being manufactured. He sees that the big machines are nothing but enlarged editions of the early and smaller ones. He knows that with a change of size there should be a change of design. He knows that although a granite rock weighing a few tons will not be kept suspended in air by a heavy wind, a small part of the same rock will be carried away by a breeze, and may be kept suspended by a very slight current of

air. He knows that the small particle of granite has a greater superficial area in proportion to its weight. He sees on every hand that a change of dimensions frequently entails a change of design.

He also sees the opportunity to effect a great saving by building the large machine for its special service, and not on the exact lines of the smallest model.

The failure of the management to adopt his plans seems nothing less than unreasonableness to the inventor, for like other mortals he is a trifle slow at grasping the fact that no two beings have exactly the same point of view or the same quality of sight.

Another inventor sees a chance to make further improvements in the small machine, and he is disturbed because there is a ban on changes. He feels that the mechanical success of his previous work should be a sufficient guarantee of the economic advantage of the last proposed plan.

If an attempt is made to show him that the ban on changes is absolutely necessary from an economic point of view, it is found that the reasoning does not get the same reaction

in his mind as in that of the manager. To him the great advance of the new scheme fully warrants the temporary expense.

The *efficiency engineer* is also strenuously urging the complete adoption of this or that particular scheme. He knows they are good, and while all may agree with him in principle, considerations of habit make others want to adopt these methods only as fast as they can be assimilated. They know that the inertia of the human mind and body must be reckoned with. In some cases they may wish to leave a trifle more freedom of movement than is absolutely necessary for the work, in order to give the worker a more natural experience. For there can be no doubt that a certain freedom of mind and body is essential to normal health and to the happiness of man. In the old-fashioned scheme of working, the average man's work involved a trip to the blacksmith shop, the emery-wheel, and the stock-room, where he could exchange items of news and jokes with others. His trip there gave his mind and muscles a restful change, and although it consumed time, it kept his mind and body nearly normal.

THE MANAGER'S VIEW

The *important duty of weighing up* these *various* views devolves on the management, and its action should be in accordance with the complete and corrected view. It must consider the subject from a top viewpoint, and must then act.

The manager keeps in mind that the machines must be built, purchased, and used by human beings, so he carefully studies their peculiarities. He knows that change of thought or habit requires time.

In looking over the history of one of the companies engaged in machine building, we find that the cost of the labor has been lowered to about one fifth of the original. In view of this and the fact that a very slight change in model sometimes involves a temporary increase in the cost of labor threefold or more, we see good reason for reluctance in making changes, even though we know that two or three years later the labor cost may drop as low as that previous to the change in model.

The inventor, the promoter, the salesman, and the oversanguine manager do not always foresee such things.

The manager sees the enthusiasm with which the selling organization hails the new model. He realizes that they know the faults of the previous type, and he also knows that no one knows the faults of the new, but he lets it go. Some enthusiasm must be had, even if it be dearly purchased. He knows there will be many a troublesome delay due to the newness, even if the whole scheme proves very much better than the previous type.

This manager knows that his business success rests on the facility with which the machines are satisfactorily built, the readiness of the buyers, and, last but not least, the facility with which the product is used. The facility with which the product will be used is to his mind almost beyond overestimation.

THE VALUE OF A MARKET

In estimating the value of an industrial establishment it is customary to guess at the value of its market.

In the machine building industry it is based on the satisfactory or profitable use to which the product is put. This satisfactory use depends largely on the number of

men who can and who wish to operate the machine.

This may not always be apparent, for the particular machines are usually purchased at the direction of some of the head officers. On the surface, it would seem that the availability of good operators had little or nothing to do with the case. A closer investigation, however, brings out the fact that it has very much to do with it, for machines will not be in demand for which operators are not available.

It is not necessary that an experienced operator should be waiting in each plant for each machine that is purchased, but it is necessary that each machine installed be set to work satisfactorily in a reasonably short time. For a failure to be satisfactorily used bars further purchases by all who may have known about the case.

The facility with which a new man may be instructed depends, of course, on the simplicity of the machine and the extent of the general education regarding it in the minds of the foreman and various workers who are in position to affect its output. And furthermore, a machine which has the name of giving sat-

isfaction is given a little more patient effort in starting and in breaking in a new operator.

But the real basis of the value of the market for the product of a machinery building company depends on the facility with which its product may be used, and this should be one of the elements kept in mind by the manager of a machine manufacturing plant in deciding on improvements and changes in his product. He should always remember the human characteristic in the user.

IMPROVEMENTS OFTEN BRING TROUBLE

Improvements or changes should not be made that are not readily assimilated by the maker, the seller, and the user. Changes that require effort to digest may be wholesome in their stimulation of receptive faculties of an individual and an organization, and they may be full of glory, but they are not to be indulged in too freely.

Changes that are in the direction of simplicity and actual betterment by avoiding some excessively objectionable feature should be tolerated, but the manager knows from past experience that each new improvement is

full of trouble to the maker and to the user, and that a *new thing is not a profitable thing till it is an old thing*. When it is an old thing its faults are all known, and then the sanguine inventor and the selling organization generally puncture the profits by inducing the management to take the next step forward.

There is neither an intent in this to belittle the work of the enterprising optimist nor to advise stagnation in machine design. A certain amount of progress must be made in nearly all industrial establishments at this time.

The fullest possible comprehension of this problem of human inertia, in matters of change and progress, should be in the mind of every officer of an organization. Every workman and foreman having a desire to make suggestions on helpful lines should get this fact firmly in mind and measure every new plan by it.

PROGRESS MUST CONTINUE

But, you ask, is there to be no progress in the industrial world? Will the progressive ones die out and only the ultra-conservative survive? Is there to be no word in favor of

progress in at least some of the departments of industrial organizations?

Should not some words be said right here setting forth the advantages of invention?

You have doubtless anticipated the answers to each of these, for you know that no rational being would in these days advise throttling invention or blockading progress.

We know that the fittest for surviving will be the intelligently progressive and that there should be a gradual progressive change in every department.

Invention must play its part in the really desirable advance, but so much has been said about the wonderful economic advantages of this and that scheme of management, and this or that invention, and so little has been said on the inertia problem, that there seems to be a need of a few words on the latter, to strike the true balance.

CAPACITY FOR NEW IDEAS

The assimilating capacity of the industrial world is the real gauge of the progress which should be indulged in. This capacity to take in new ideas and to work by new methods is

not the same in all beings, and it is not the same in all organizations. There are ways by which it may be measurably increased. New views are more readily digestible if presented by enthusiastic advocates, as this stimulates an interest. Any attempt to forcibly inject new ideas only results in indigestion.

The assimilating capacity of an industrial organization can be greatly increased by any scheme that awakens an interest. The controlling policies should include advance in efficiency and generally in the quality of work turned out, but this advance should not involve a break in the output. It should be based on a knowledge of the whole business. In other words, it should not only pay in the long run, but if possible it should pay from the moment it goes into effect.

MONEY NOT THE ONLY DIVIDEND

The major policies of management that should be known to the inventor are those which have been adopted to make the business "pay." Not necessarily to pay in dollars and cents today, but to pay in every sense, and in the long run, in dollars and in other things.

It cannot pay in dollars if the other things are missing. By other things are meant good organization built on best conditions of mind and body for each of the beings included in the organization. On such things the stability of the organization depends.

No matter how much the manager of a business may wish to run it for other things exclusively, or for dollars exclusively, he will find that one is not attained without the other. He is forced to run a business for the dollar if he wishes to make an ideal organization for each member of the human family included in it. And vice versa, he must work toward best conditions for all the workers if he wishes to protect the capital invested by making a stable and fairly long-lived organization.

This statement is inserted here to clear away doubts as to the real value or necessity of "making a business pay," and to make it clear that no thought is to be tolerated of any scheme of management adverse to the real interest of the workers.

The men selected for each of the various positions should be men who are fitted to fill these very positions. This does not mean

mere physical and mental fitness; it means each position should be filled by one who wants it, one who knows he is "better off" in it than in any other place he can find. Dissatisfied men are burdens. It is better to have each position filled by a man who is barely competent to fill it than to have it filled by a man who should have a much better position.

Of course, this is the ideal, and all moves should be made in this direction whenever it is possible. As a rule, it is easier to find men on this basis than to find men who are bigger than the office. This scheme leads to more promotions in the organization and has a stimulating effect on all concerned.

IV

INCREASING THE ASSIMILATING CAPACITY

WE have said that all changes should be of the digestible kind, and the feeding process should not be a stuffing process; that the ingestion should not exceed the digestion. We have also briefly mentioned the importance of keeping the digestion tuned up to the best speed by having the organization in a condition to most readily take in changes.

That we must make some allowance for inertia of thought and habit in all mortals goes without saying, but the exact amount to be allowed is very difficult to estimate.

Successful management depends on the degree with which a man can estimate the receptivity of other beings with whom he deals. This knowledge of receptivity should include the thought and action of men all the way from the unskilled worker to the directors, and also that of all men in other organizations in any way affected by his organization.

Just as food is more digestible if agreeable to the palate, so this receptivity or assimilating power may be increased by presenting new ideas and methods in agreeable form. A full realization of the effect of this inertia of thought and habit makes the great efficiency of specialization more comprehensible.

It is this human side that is the key, and if we do not act in full accord with it we will probably be working against a great handicap.

The inertia works two ways. It hurts a progressive man just as much to be tied to a work that requires no brainwork as it hurts a sleepy member to be disturbed by progressive talk.

SELECTION OF EQUIPMENT

In the organization, the selection of methods of working should always be on the side of those that facilitate progress. In the selection of machinery, some thought of possible changes should be allowed consideration.

By this statement I have no intention to drag in contested theories or any particular interest, but I do want to show that the hope

of progress is greatly increased by use of methods that favor it. Inertia rightly used, then, is for ultimate progress, and not against it. Specialization is also actually for progress, when that specialization is progressively constructing a given machine.

Some years ago the builders of a certain type of machinery found there were many duplicate pieces to be made that came within the working range of a certain variety of special machines. They figured the saving in net cost of labor of machining these pieces could be reduced from 75 per cent to 90 per cent by the introduction of these machines. But they were embarrassed at the conflicting opinions regarding the advantages of the various machines in the general class called special.

The machines which would save 75 per cent of the labor cost almost as much as the machine that would save 90 per cent. On a further investigation, they found that for a given output the machines that would save 90 per cent would cost, with their first equipment of special accessories, from three to four times as much as the other, but that constituted no barrier. The directors voted to introduce the machines

which would effect the greatest reduction in labor cost. But let us see what has been the result.

LABOR COST NOT THE ONLY CONSIDERATION

They found that the introduction of these machines required running work through in larger lots. The larger lots required bigger storerooms for parts. The machines, which were more or less self-operating, effected their saving not by pushing the cutters to their full limit, but by so reducing their cutting speed and feeds that one man could oversee a number of machines; but in the regular order of work the operator seldom happens to be at the right machine in time of trouble.

Three times the number of buildings were required to give the required floor space. As years passed, it was also found that making stock in larger quantities resulted in having a lot of obsolete stock on hand. It was not clearly shown in the annual statement, because it appeared as a large inventory. It was not charged off, because it might be used in the future. There was also inventoried at full

value a lot of obsolete accessories in the tool-room, besides a number of machines that were limping along trying to make use of tools that were designed for other work. It was found that unbearable delays followed the change of design. The average time for a lot of special tools was about six months. Six months seemed a long time to be handicapped with this inflexible, inadapttable equipment.

The extra stock, the buildings, the first cost of machines and first tools, the accumulative cost due to new tools, the upkeep of the regular tools, all seemed bad enough without the added handicap of a barrier to progress of an inadapttable equipment.

OUTPUT PER DOLLAR INVESTED

Of course, no one could have foreseen a few years ago that the high-speed steels would so change the scheme of cutting metals that it is advisable to have a man watching every cutting tool and every expensive machine tool in order to get the biggest output per dollar invested in it, and no one knew ten years ago that form tools are not often the best for turning

off metal. All this has transpired within a few years, but every one should know that capital invested in a business must be put where it will do the most good, where it will bring the largest percentage of return.

If it is not so placed, the business is sure to be throttled. If it takes ten times as much capital to get a given output, and the net result does not increase the security of the investment or the profit per dollar invested, it is evidence of poor management.

The inadaptability of an equipment might be tolerated by the average optimistic manager because he feels that he must win under the present conditions. He knows that the problem is perplexing without the addition of probable future needs.

FUNDAMENTAL PRINCIPLES

Our progress and present position in the industrial world is due in a large measure to our conformity with the great fundamental principles of industrial economics.

Our present standing should not make us unmindful of the new conditions, conditions incident to greater complexity of both mechan-

ism and industrial life. The conditions are best understood from the human side, after we have made ample deduction for our own aberration of view.

In the foregoing I have stated the importance of best understanding of our fellow-man, and that it results in conclusion that he is really a good fellow, fairly disposed as we are.

I have shown that we all do not possess the same views.

I have shown the power of habit and how it makes for stability and progress.

I have shown the effect of inertia of mind and body of ourselves and others.

I have had in mind that inertia was the property of an object to continue at rest or motion, without change, and that progress might be made by intelligently working to overcome the inertia of stagnation.

If we will all continue to work as we have worked in the past, we will continue near the head of the procession. Just now we are observing a very progressive spirit in other countries. I think we were and are leaders in many respects. I believe we can continue to

gain, but if we do, it must be along the lines of intelligent specialization, progressively specializing in each line of manufacture of a given machine. It will not be contrary to laws of habit and of inertia.

PART II

SOME NON-TECHNICAL PHASES OF
MACHINE DESIGN

V

SOME NON-TECHNICAL PHASES OF MACHINE DESIGN

THE following chapter is given in its original form as a lecture to the Engineering Society of the Stevens Institute of Technology.

Its value in furnishing a side-light on the subject of habit, to which the preceding chapters have been more directly applicable, lies in its emphasis on the importance of the inventor (or designer, if you prefer) having clearly before him at all times the effect of habit methods of thought and action both in himself and in all others. These modes must be conserved and combated in himself when building up favorable mental states. He must build on habit in order to have his mind continue in its application to a chosen subject, and he must combat any tendency to follow habit lines of thought that have been established by observation of the older forms or methods. His inventions must be of a kind that will be readily made, sold, and used by

men whose habits of thought and action he cannot readily change.

This should be of value not only to the designer, but also to those who direct or co-operate with him.

NATURAL FITNESS

One of the first questions that arises in the mind of one who intends to undertake machine design is, what constitutes natural fitness for it. There seems to be no positive basis on which to determine in advance a natural fitness for this work, but there are certain temperamental characteristics that undoubtedly have much to do with the success.

The temperament should be one favorable to continuity of thought along a given line, as well as one that will by nature take an intense interest in the subject.

If these characteristics are missing, it may be due more to the distracting interests that in these days crowd in upon the mind, than to a lack of natural aptitude. The absorbing interest, however, is essential, and it may be developed by conforming to well-known principles of orthodox psychology. Self-torture

or hard driving is not nearly as helpful as a strong inner purpose to keep the chosen subject in the real center of conscious thought.

The subject that comes to mind when there is a lull in the outside demands on the attention, or one that is insistent on taking possession of the mind, even when other matters are objectively more in evidence, — *that subject* is the one that holds the center of the inner attention. That is the controlling idea or purpose. Ordinarily, it is some diversion; occasionally, the haunting bugbear of some unfinished work or obligation. If the mind is dominated by such ideas or any other than the real problem in hand, the individual is seriously handicapped.

When a problem of machine design is undertaken, the mind must make it the real center of attraction. To one having an average endowment for such work, this is not a difficult task, but to get the best results it should be rightly undertaken.

REPEATED THINKING

A chosen subject is brought, with some lasting effect, to the center of attraction by

repeatedly bringing it into the mind at the moments of lull in the pressure of other affairs. The astronomers wait for the moment of best seeing, and the designer must wait for the actual psychological moment.

The best seeing condition for the astronomer is due in a small measure to his own physical condition, and in a large measure to atmospheric conditions, but the most opportune time for clear-headed vision of the designer is due mostly to his own physical and mental condition.

Probably no two men have their minds equally affected by their environment or their physical condition, but the fact that there is a most favorable time and condition for such thought and work should continually be borne in mind. Without this a man with natural endowment may try his wings at flight at an inopportune time, and if he fails he may be firmly convinced that he was never made for flying.

This undoubtedly applies equally well to other kinds of work. It may not be strictly true of a perfectly normal man (if there be such a creature), but it is truly applicable

to many workers in this and similar kinds of work.

This phase is mentioned in order to make clear, not only how a designer should work, but the thought that should be kept uppermost in the mind of one who is trying to do this work.

The physical condition is more or less dependent on the mood, and to a great extent the mood is dependent on the condition of the body. The strenuous gait is seldom the best, and, of course, the extremely indifferent one is of little value. The best for the average man is one born of a quiet environment, with mind and body in a fairly restful condition, or still better, in a rested and fresh condition.

CONCENTRATING ATTENTION

The quiet end of the day is almost as good for clear thinking as the early morning, especially if the day has not been over strenuous and the activities have been gradually tapered off.

There are many instances that would seem to show that the strenuous gait is the best, but nearly all of these evidences are questionable. When finally simmered down, the

good work done under high pressure is frequently due to latent ideas that were the product of quiet thinking. The mood and the dominant idea may be predicated as necessary.

As already stated, the habit of thought most favorable for the persistence of a single group of ideas is attained by the practice of switching the attention back to the desired subject.

This should be done at the opportune time. The subject should not be habitually forced on a tired mind. It should not be taken in as a painful duty, but it should be made the one thing of interest. Really valuable results can only come along the line of the dominant thought. All other work lacks directness. It follows precedent to an unnecessary extent.

INTEREST MUST BE AWAKENED, NOT FORCED

Another way of saying all this is that the designer must get interested in the particular problem, and he must have an interest that crowds out all other thoughts, even thoughts of similar work. It is useless, however, to say, "get interested in the work," unless we suggest a way to awaken interest. Surely,

we know that interest does not come at mere bidding, and that it cannot be forced by hard work. But it can be induced by an easy process in a normal being, providing he has not already too firmly established a set of habit thoughts of another kind.

The normal being, by persistent intention, can establish the desired thought habits by returning the preferred group of ideas to mind. Interest is awakened by this comparatively easy process, and when a genuine interest exists, the actual work follows as a natural result, and it is a pleasure instead of a drudgery.

This is not intended as preaching in any sense; but only to bring to mind facts known to all, with the view of implanting these facts in the mind of the machine designer.

Some designers have done excellent work with no thought of psychological problems. But in this more strenuous age it seems best to take advantage of every aid to the desired end.

The intricacy of mechanism has reached such a state that new designers are almost overwhelmed with the mere thought of trying to comprehend the existing machines. But

with the advance of the world of machinery there has been a better comprehension of the working of the "thinking machine," and we must take advantage of this knowledge in order to win out. It is particularly needful now to study its most efficient use. We are getting to the point where mental energy saving methods should be used.

It is not necessary to go beyond the bounds of orthodox science for schemes for getting the best results from a given mind. We have known for centuries that men tend to habits of thought as well as action, — that thought habits are like ruts, and these are encountered wherever the mind travels, and these ruts bring the mind back to a certain central group or community of groups of ideas.

ESTABLISHING USEFUL RUTS

The real secret of success is in establishing ruts of a useful kind, ruts with switches that may be operated by the mind at will, or that work automatically when the mind would otherwise wander.

Since even fleeting thoughts are germs of acts, it takes no great effort or self-torture if

we will but understand the processes and smoke out the undesirable germs, and allow and encourage the growth of the preferred groups of thoughts. This may be called a lazy man's way of doing things, but it is the way to conserve the mental and physical energy, and it gets results.

In saying that the problems of the work in hand should come automatically and agreeably into the mind when there is a lull in the impression being made by other things, it is not the intention to convey the meaning that one must have no other aim and ambition.

The mind is constantly receiving messages through the senses. These are fired at a rapid rate. The human mind automatically selects from these messages those that fit into the habit of thought.

The habit of thought should be formed in accord with one's best interest.

It is forming right thought habit that is essential to the machine designer.

This is best accomplished by the already mentioned scheme of diverting the attention from distracting impressions and returning it to its proper channel.

Although it goes without saying that this should be done in the strenuous hours of work, the really efficient and easiest way is to do this thought diverting at the lull — the quiet — the moment when all kinds of fleeting thoughts travel through the mind.

One easy way to build up this habit is to begin by displacing annoying thoughts with thoughts of work problems, and after a time it becomes easy to cut out every other thought.

PROBLEMS TO CONSIDER

In taking up the problems of design of a machine, there will be found an almost endless number of elements to consider. The strictly mechanical problem of the best machine for the purpose never stands alone.

What is the measure of the best machine? How much can be spent on its design and construction? How much work is to be done? An endless variety of questions at once crowd into the mind for answer.

It is doubtful if all the elements could ever be tabulated in any form that would be a positive guide in shaping the final result, but in a general way the designer should make a

fairly good guess at the kind of standard toward which he should work.

There are, doubtless, men capable of carefully weighing the almost infinite number of variants, but such men usually lack the intuitive scheme of work, on which the inventive side of a designer depends.

For the ordinary mortal the best process of working is to keep a vague picture of the whole requirement in mind while concentrating on some one phase.

When the inventive qualities are to be called into use, the economic side, the business side, the manufacturing, the selling, the personal profit in cash or glory, all these must be absolutely crowded out of the center of the mental picture. Even fleeting thoughts of other elements seem to prevent the inventive functioning of the mind.

In like manner the problems of manufacturing, selling, patents, business organization, must each be given a separate consideration. The interval between taking up the various questions should be as wide as possible. The mind seems to require a previous notice of days or weeks or more in order to take up

any one of these problems, at least, with any hope of success.

DESIGNING BY THE SQUARE FOOT

The ordinary work of machine design, in which well-known parts are grouped to accomplish a given end, without much thought of attaining anything approaching the best,—such designing is like painting a fence, so many square feet of paper should be covered per day. But the real higher type of work cannot be measured in this way. It requires the forethought, the close application, the keen interest, and the comfortable idea building.

Designing by the square foot is, however, a good preparation, and many a good brain has been developed by such work.

The importance of designing a machine to meet all the conditions necessary to success from a mechanical and business standpoint is fully recognized by every one. But the grouping of the ideas in the mind while working out the various phases must not be hampered by the bewildering picture of all of these problems, each demanding consideration at every move. The phase in hand must have

the concentrated attention and the best conditions for its solution.

The harmonizing is an after-process which must be worked out by a series of compromises after the various component elements have been almost independently considered.

INVENTION SHOULD NOT MIX WITH DETAIL

In working out the mechanical schemes no energy should be wasted in trying to make the sketches correct in proportion. The very functioning of the brain along the draftsman's line shifts it away from the inventive mood. The exact drawing frequently shows the necessity of change in general scheme, but that is only one of the after-steps.

The fundamental idea is the starting-point, and must be sketched out as fully as possible without losing the very frail thread of thought.

A clear view of the scheme is not to be obtained on demand. The schemer must wait in patience, as the astronomer waits for steady air, and, like the astronomer, he must have every facility in shipshape. The clear view is only clear to the watching eye.

The coast-wise skipper in making a fog-

bound harbor will see a buoy through a slight shift in fog, while a landsman might look in vain.

The wanderer in the happy dreamland of mechanical scheming must not be looking for complete drawings, specifications, and working model of the invention he wishes to bring into the breathless and waiting world. He must be looking through the mist of the thickened senses as the skipper looks through the fog. The buoy and the scheme may be never so faintly shown, but yet with sufficient clearness to give a positive guide for the course.

Inventive schemes cannot be forced by strenuous effort. Such effort may result in slight refinements of a given type, but never would have invented the DeLaval or Tesla turbine.

It is not my purpose to belittle the great work that has been done in improving existing machines, for this, after all, is the real great work that must be done. It is the work to which the world owes its greatest debt for progress in material wealth. Furthermore, it is a phase that must be considered in connection with every invention before that invention can become of value to any one. But

just now we must consider how the inventor must work while dreaming out the fundamental ideas of a mechanical scheme.

The clear view of a mechanical scheme is more likely to come after a good night's rest, particularly if the schemer has retired with the problem in mind. There are times when invention comes under severe stress, hard physical work, and mental anxiety, but the most usual time is after a sleep which refreshed mind and body. After this the inventor brings his scheme to the drafting board, to patent office, to the factory, and to the market, and in each case he encounters barriers.

THE HERO OF THE ERASER

The drafting board may show that no such arrangement of parts can ever be made, that the whole scheme must be altered to make it practical. A real hero is required for the work of juggling the elements of a drafting board. He must have patient endurance and sufficient strength of character to use the eraser heroically, for the eraser is mightier than the pencil in the drafting-room. There are a thousand

valiant knights armed with pencils to one stalwart pusher of the eraser.

In the drafting-room the work of harmonizing must go on; compromises must be made between the ideal scheme of the dreamer and the requirements of the manufacturing and selling departments.

Next to the noble knight of the eraser comes the idealist who has been toughened by experience in the cold world.

The idealist aims to design and construct a *perfect* machine. He is encouraged in his work by seeing a little clearer each day, month, and year of the time spent in the right kind of application to his work. He knows that the work of last year is faulty, that this year's work seems nearly perfect, excepting for a certain slight change that has just entered his mind. He cannot think of allowing any machine to be made without this later improvement.

He is inclined to the optimistic view, his memory works best on the good work of the past, and is extremely poor in holding afresh the view of previous mistakes.

THE TOUGHENED IDEALIST

The toughened idealist may not look or act like an idealist, but in reality his idealism is one of the practically-wise construction. He allows his memory to hold all that is helpful of the past, both of the blunders or successes.

The dreamer who has been toughened by experience is one who lets his rational brain have control. He ranks next to the stalwart knight of the eraser, because he has the courage to arrest the endless tinkering of design in order to get something done. He will not let the family freeze while he is thinking up some grand scheme of sawing and splitting wood by magic.

A most cursory glance at the machinery in use in the world will show that the work has been done by imperfect machines. A study of the design of any machine brings out the innumerable shortcomings.

If we see a machine that seems perfect, it is perfectly safe to set it down in black and white that we do not fully comprehend it. It is safe to say that the only perfect machine is the new model that is to be tried very soon.

With these facts in mind it does not require very much courage to go ahead with an imperfect design, but unfortunately these thoughts will not stay in the mind of the average mortal. They are crowded out by the flood of ideas for still further betterment. That is why it is just to give high rank to the man who had courage to go ahead and build, even when he realized the faults of a design.

Perhaps one of the aids to this action is the knowledge that the apparent opportunity to improve a design may only be apparent. In reality the change is only a change, and is no betterment, a very common outcome of such ideas. The knowledge of the great array of failures of such "improvements" is wholesome and helpful to bear in mind.

CONFORMING TO ECONOMIC CONDITIONS

In designing the parts of a machine, the need of trimming here and there, of giving up this or that ideal form just to get things together, must be seen and done unflinchingly. And in the same way the whole scheme must be made to conform to the economic conditions.

If the machine under consideration is like

a machine tool, and is to be offered for sale, then the manufacturing, selling, and use must be taken into account. In machine-tool design a wholly new invention is an exceedingly rare thing, and a successful new machine is still more rare.

We must remember our *own* tendency to follow precedent, and we must make an effort to see the problem in its natural form without being misled by the solutions evolved by others.

GETTING BACK TO NATURE

This scheme of getting back to nature — of weighing up the elements unhampered by precedence — is the one most helpful in original work.

Designers strive to get out of the ruts of habit of design. They try to avoid making a railway carriage like a horse-drawn vehicle. They eliminate the unnecessary elements of previous designs. They try to make the best piece of mechanism for the purpose under consideration, and even if they are wholly successful in this respect, they may after all be doomed to disappointment if they have failed to take into consideration that others

cannot be easily changed over to the new idea. It is one thing for an inventor to get himself out of a rut, and still another to get others out.

This knowledge of the force of habit of man should therefore be used in two ways: —

First, when the designer is trying to make the most natural machine for the purpose. Then he must overcome his own tendency to follow precedent. Second, when considering the kind of a machine that can be easily made, sold, and used, he must give due consideration to the inertia of others, for their inertia he cannot hope to quickly change. Reformers in this world generally have a hard time whenever they underestimate the inertia of men's minds and bodies.

A designer of machinery, by close application to his tasks, should obtain a clearer view than it is possible for others to possess, of the way a machine should be designed, made, and used. It is not necessary to assume he has a better brain. An ordinary mind applied to a given subject sees it more clearly than an abler mind which has not considered the subject with the right interest.

TECHNICAL VIEW INSUFFICIENT

But whether the clear view of the designer is due to peculiar fitness for seeing such things, or to proper application, the fact remains that this clear view of the technical side is insufficient in itself. The man with the clear view must also realize that others do not get the same view. He must know that the mind automatically takes in things of interest to it and wards off others. Even when the individual apparently tries to comprehend something in which he has no special interest, it only results in a superficial mental impression, one that has no appreciable effect on the actions.

This failure of mankind in general to grasp the advantages of a new mechanism as it appears on paper is only a slight part of the troubles to be encountered by a progressive designer.

He has to contend with habits of thought and action of all the human beings affected by the new machine. This includes the entire group of men in the manufacturing plant in which the machine must be made, the business

organization both in this plant and the one in which it is to be used, and, after all this, the greatest obstacle of this kind is to be met in the man who uses the machine. For it is in his hands that a machine must prove its value.

When we consider the inertia of mind and body, it is truly marvelous that there has been any progress in machine design. In fact, if the machine-building trade were in retrogression, with only a few new men being taken in there would be little or no excuse for making machine tools of new design. The older workers would get along about as well without the improved machines.

This is not said in a spirit of faultfinding. It is a great fact that we should grasp if we are to design machinery successfully.

It is difficult for the man of sanguine temperament to really accept this view, and it is also hard for one who is continually searching for knowledge. But it must be appreciated, and all work must conform to this principle, if it is to be pushed forward along the lines of easiest progress.

Accepting this view is no barrier to progress.

It will not ultimately delay the work of a reformer if he is induced to act in accordance with this principle. It only prevents a wreck.

EASIEST WAY TO IMPROVE

Inventions of complete novelty and of great economic value have attained success going in opposition to this principle of conformity to the habit of the world. But the easiest way is to direct improvements and inventions along lines that are the most readily assimilated by the minds of the beings to be considered, and this may be said to be one of the master-keys to economic success.

The work of building the first model of a new machine may be under the direct supervision of the inventor, and if only one machine is to be made, the inventor can follow it wherever it is used. By patience and industry he may instruct some one in the use of it, but in these days there is no chance for a great economic success in making just one machine, or in fact any machine for which there is not a large market. Hence, we will confine our attention to machines made in such large

quantities that the complete supervision of manufacture, sale, and use is beyond the capacity of one person.

For all such machinery the design must more or less conform to the thought and habits of work of all concerned. Some of the most direct designs have failed to meet with success just because the inventor did things in an unusual way. The unusual way is a blind way, and is difficult to find. In some instances it amounts to no way at all, for it is never used.

AVOID OBSCURE PARTS

If a radical change in design is to be made, the new machine should be one that will be the most readily understood. Obscure parts or unusual means should be avoided.

If moving parts must be covered, some way should be provided for convenient observation. It is the obscure departure that is the most troublesome, and it is the obvious thing that offers the least resistance to progress.

There is a chance to progress by obvious devices, and such progress is enjoyed by all, from the makers to the users. It stimulates their weak but wholesome appetite for progress

without the economic loss usually entailed by new things.

The real new thing requires thought in its construction, its sale, and its use. Whatever requires thought delays action.

If we were required to think out each move of foot or hand, or even tongue, the motion of these members would be greatly reduced. Business is transacted and work is done in the most economical way when it is the result of experience and habit.

Thinking, of course, goes on more or less according to the kind of work and the kind of man, but in many cases it is, after all, only "habit" thinking that really goes on without much conscious effort.

The delay in progress of business and work which is caused by the need of the real brain-work that is required by new things, is one of the most important points to grasp and keep in mind in making any change in a machine or in bringing out something comparatively novel.

GETTING OUT OF THE RUT

We have said that an inventor's success depends on his getting out of the rut of thought

and practice. That his endeavor must be to make a machine that fits the economic and practical needs. That he must remember that his invention must be truly great if he can neglect the fact that others will not get out of the rut without a rather severe jolt. In fact, he must consider that the success of his work depends more on the readiness with which it will be understood and used than on its merits as an ideal piece of mechanism.

If the inventor gets his cue from the business head of an organization for building machinery, or from any of the members of the commercial side of the business, it may be a cue that indicates the great need of something distinctly novel, something radically different, and with more "talking points" in its favor.

This is not always the case, but there is generally more optimism among the pushers of a business organization than in the actual workers or users of the machines. But the designer should keep in mind the real needs and the real obstacles to success.

The favorable features in machine design are: directness of mechanism for the purpose; its simplicity and its efficiency; its adaptabil-

ity to the habit of thought and action of makers and users.

The obstacles to its success are any of the features it may have that cannot be readily comprehended by those who are to build, sell, buy, and use these devices. It is of little value for real success for a machine to be one that is readily understood by a draftsman or manager, or that it is one that may be made to perform wonders in the hands of a skilled expert.

The real economic success depends on the number of machines that will be used. The number of machines that will be used depends on the readiness with which the real workers take hold and manipulate the machine.

To get a true conception of the value of a machine, it is necessary to look at the showing of a business engaged in its manufacture. In estimating the value of a machine-building business for this purpose it is customary to speak of its "good-will."

THE TRUE VALUE OF A BUSINESS

All have recognized that a "going" business has a value that differs from a dead one, the same as a live horse is of greater value than a

dead one, but it has been a trifle difficult to locate this value. The inventory that contains no item equivalent to life may not reflect the true value. The real value may be greater than that which would be indicated by the assets. As a matter of fact, the inventory is usually made to reach a figure which will tally with the earning power. The earning power of a machine business is largely due to the volume of business on each machine. The orders for a given machine may be coming in, responding to an aggressive campaign of advertising or missionary work. But as helpful as these are, they are relatively small compared with the effect of a host of workers who know how to operate the particular machine and who want to do so, as well as the number of men who have a half-knowledge and a whole-size desire to learn this trade of operating a given machine.

This extra value is due to the fact that this increase in volume of business establishes a repetition of thought and work, and this is its real foundation of success.

If a machine is one that is to be operated by a human being, it must be built to conform not only to habits of mind and body, but also

to his mental and physical make-up. The man who remarked, while standing in line waiting at a box-office, that he would rather walk ten miles than stand five, expressed an important fact that we should keep in mind in designing machines. The human being must neither be unduly restricted in his freedom of action nor overtaxed with hard work.

PHYSICAL CONDITION OF WORKER

If the use of the machine induces either an adverse mental attitude or physical condition of the worker, it will sooner or later be adverse to the economic success of the machine.

We have indicated some of the problems and have suggested the well-known method of mental control for this purpose. A keen observer of men and machinery may not require as much of the so-called practical experience; another may need many years of actual work.

The practical experience in the various departments of machine construction, its sale and its use, is undoubtedly almost absolutely necessary for the average man in this work.

Its value is primarily to give an opportunity to see things in actual operation. The

shop affords an opportunity to see how a machine stands up to its work, where it is weak, and a thousand and one points that can best be seen in actual operation. But there is still another phase that is comprehended more readily by the practical experience, and this applies to the various departments of business as well as to the works. It is the knowledge of the men and their mental make-up and attitude.

A keen observer soon realizes that successful life in the machinery world will not come easily to any one who lacks a good understanding of others in the field.

ALL MEN ARE HUMAN BEINGS

One of the first things we learn in the works or office is that all men are really human beings. The second one is that the meanest one is only so because of certain physical or mental conditions that are the direct result of natural law. Usually it is not necessary to drag in heredity, for we find ample cause in his environment, within our range of vision.

As a rule, a good understanding of men insures a wholesome regard for them, while fail-

ure to understand the other fellow (or the equivalent, the failure of the other fellow to understand us) may bring out many things that make us feel that he is not one whose feelings or interests should be considered.

To any one that has had experience in the shop and a fairly well-rounded business and financial experience in this particular field of work, the other fellow is invariably a good fellow whenever there is a chance for a fairly complete understanding.

If we can accept this statement tentatively, and follow it up by a determined purpose to actually feel it, then we have obtained something by the royal process that would have otherwise required much time and perhaps some unpleasant experiences.

This knowledge is essential to success in designing machinery. True, many have been successful with a very different attitude, but engineers of the future must see to it that as many of the phases are as favorable as can be made so.

Regarding the absorption of the knowledge of working mechanism in the works, this is greatly facilitated by a wholesome relation-

ship with the workers, and it is greatly handicapped without it. Therefore, it is one of the cardinal points for the machine designer to get thoroughly acquainted with other men in the work so as to know their likes and dislikes, as well as the mechanical needs.

CONTROLLING THE MIND

The mind acquires the clearest observation by the scheme already mentioned for creating interest, viz., by repeatedly bringing it back to the subject whenever it is found wandering.

The truest view for this purpose is one that results from an attempt to discover the most natural lines for accomplishing the purpose for which the machine is wanted. It should not be born of precedent. It should not follow the lines of thought of other designers.

Another very fruitful scheme of working is to hunt for obsolete features in existing machines, features that were required in other days but have no use now. Such things are frequently found in machines, and they are there just because some designer has followed blindly.

All designers follow more or less. We

have shown the great need of following the set habits of users, but we should make a distinct attempt to get back to nature; that is, to see just what is best for the purpose, and to get the most direct and natural means. If this is too much of a task, just hunt for the obsolete features. Above all things, we must not try to follow another's work. We too often follow unwittingly and to our misfortune even when we try to keep out of the rut.

Machine designers who have done original work will tell us that it is easier to do good work by striking out on new lines than it is to follow the work of others, or even to tinker over some of their own inventions of other years. It takes more of a mind to take up the work of another and change it than to start out in some original scheme.

The machine builder knows that the success of any machine depends on the clear-sightedness of his designer and the oneness of purpose of all the heads of all the departments devoted to the construction, sale, and oversight of the running machines in the hands of the users. And last but not least, in these days of supremacy of specialization, he knows that

success comes only to the largest group of men organized for this particular kind of work.

COÖPERATION NECESSARY FOR SUCCESS

He knows that a given machine must have a group of men devoting their best thought and energies to bring its greatest success.

This group may be a separate organization, operating as a separate company, or it may be a part of a large organization devoted to a variety of purposes. But if it is a part of a large organization, it must have an absolutely independent organization with the free management of business, and it must be unhampered in the control of its construction, sale, and direction of its use.

The men engaged in production, in the business, or in the operation should have no other work. And as already stated, this group of men should be larger than any other group devoted to a competing machine.

Workmen must not be changed from one class of work to another, excepting for promotion, and business men should not be expected to know all about two or three machines of unlike characteristics.

Improvements should be sparingly made. Any improvement that requires a change in construction or operation may be disastrous financially.

This may all seem extremely pessimistic. But it is only seemingly so. Experience shows it to be the true view.

If it is true, then the machine designer should know it. A mere knowledge of mechanism is insufficient for him. A large business experience cannot be purchased, and his success should not be contingent on the business ability of another. He should know how a machine should be designed, and should not depend too heavily on the views of the business men who have not a clear knowledge of the technical problem.

Perhaps some of you may feel that there are many other problems to be encountered before you will meet these which I have set forth. But we should remember that the mind holds some of such impressions a very long time. It holds them below the threshold of conscious thought, and under ideal working conditions it brings them above it when they are needed.

If you have caught my meaning you will

not be weakened in enthusiasm for new work, but you will be protected in a measure against some of the reaction due to disappointment. There is a great field for earnest workers, and it is easy to become one by working on the lines set forth.

PART III

MACHINE BUILDING FOR PROFIT

VI

MACHINE BUILDING FOR PROFIT

THE navigator in preparing for a voyage carefully examines each of his instruments. He must know the present error of his chronometer and its rate of change, and its general reliability as indicated by its past record. He must also know errors in his compasses for each point, and he should have the fullest information regarding the degree of reliability of every other means on which his success depends; and, last but not least, he must accurately determine his starting-point or point of departure.

In taking up the subject before us we will do well to follow his example.

In doing so, our task will be to examine two principal elements: one, the means on which we depend for interpreting the information that is available; and the other, the source and character of the information.

The means may be considered analogous to the navigator's instruments, and is no less

a thing than the brain or mental machinery; and the information is simply the world about us as seen in the existing things, such as machinery, methods, popular notions, textbooks, etc., all of which may be classed as environments, and may be considered as analogous to the charts and other publications of our worthy example.

Like the mariner, we must determine the degree of reliability of all these sources of information and our means for interpreting observed facts.

When we have ascertained this we will know what allowance to make from the "observed" to get the actual facts. With this knowledge we will be able to accurately determine both our starting-point and best course.

The importance of considering our own minds will be seen when we realize that every new fact taken in must in a measure conform to the previous ideas. If some of these old ideas are erroneous, the mind must be more or less ready to discard them. It is very difficult to dislodge deep-seated convictions. Contradictory ideas are not assimilated. Only one of them is actually accepted. Even when to

the objective reasoning they seem false, they frequently continue to control our actions.

Since we are loaded with the popular ideas which we have absorbed from our environment, it will be well for us to begin by critically examining our environment and the process by which ideas have been taken in. This may enable us to put out some of the erroneous views, and perhaps more firmly fix the true ideas; thereby preparing the mind for a more ready acceptance of what otherwise would be barred out as contradictory.

We shall not go deeply into the psychology of the subject, as it will not be necessary to go contrary to or beyond the well-known facts.

We shall not try to locate the man or refer to him as the ego or inner man. We shall simply say that we know that *we* can use our brains to think on any subject, and we can use our senses to collect information regarding any chosen subject.

Our senses and mental faculties can be directed to consider one element in a business, and for the moment be unmindful of the many other elements. In other words, we can to a

certain extent manage our mental processes. Just as a horse can be managed, so may we manage our brains. A driver may carefully control the expenditure of energy and the course traveled, or he may throw the reins over the dash and allow the horse to go his own gait and route. In the same way we may manage or mismanage our brains.

GOOD RESULTS WITH MODERATE EFFORT

A faster pace will not be advocated, for the present gait is over strenuous. We hope, however, to point out a way by which good results may be obtained with moderate effort.

If, in the past, the brain has been found wanting, we should not lose confidence in its reliability until we have seen how it has been managed.

Under some conditions its interpretations are absolutely correct; in fact, under all conditions that would be called fair in testing other kinds of mechanism.

Unfortunately, these conditions have not always existed. Opinions regarding important matters have been formed when accurate mentation has been impossible.

Our mental processes are infallible when the problem is simple, and may be correct when complex, providing sufficient time is allowed for reliable operation.

Two plus two equals four to every normal adult's mind. We agree on such simple sums and many more difficult, but we begin to have "opinions" when we undertake problems in which there are too many elements for us to "take in" and weigh.

Although there is a great difference between the capacities of the various minds for mathematical and other problems, each mind has its natural limit or capacity. This capacity should be known, for the mind cannot be trusted beyond this normal working limit.

When the thinking machine is pushed beyond its normal capacity, it is untrustworthy. The faulty action would not be of great consequence, if we would disregard the conclusions which it has reached under such conditions. But unfortunately we go on clinging to these opinions, "set notions," and "convictions," just the same as if the process had been infallible.

These opinions constitute our viewpoint

or knowledge, and we govern ourselves accordingly in the management of our affairs.

Just as we possess the "fixed opinions," "set notions," etc., regarding the greater problems of life, so we possess a million of set notions regarding the best form of machinery and best methods of conducting a manufacturing business.

Many of these notions have been acquired without careful thought. They have just been absorbed from our experience and environment. In some cases we may have assumed that some one has previously given the matter proper consideration, and that the existing conditions are the result of their conclusions. As a matter of fact, many of the conditions now existing in the machine shop are the result of allowing old practices to continue after conditions have changed, and this has taken place without the attention of any one.

There is no desire to belittle the opinions of others. In fact, we must depend on others for most of our opinions. But there are so many things that have been apparently left to "others" by everybody, that it is well for us to do some independent thinking, especially

on our own immediate problems. To cast a glance at least at some of our notions, just to see if they bear proof of having been thoughtfully produced or unthinkingly allowed to take form.

UNIMPORTANT DETAILS

We can neither regulate the complexity of our environment nor the number of problems which we must settle within a given time. But we can improve the conditions very much by avoiding overconcentration on unimportant details. The brain's best time and energy should be reserved for our own immediate problems; it should not be hampered by details of others.

The various officers of an industrial organization should know the ins and outs of the thinking machine on which they depend for guidance. With such knowledge each brain will give the greatest results, and without such knowledge the best brain may be untrustworthy.

One of the important characteristics of the mind is its tendency to lose sight of everything except the subject in mind. One danger

is dodged by jumping into another which we have not seen. Both dangers were plainly in sight to any one who had not concentrated on one of them.

In the regular every-day business life, we seem to have ample time to consider each problem. But in reality our great length of time is offset by a greater number of elements to consider, and a more profound effect of long-continued teaching or molding of our environment.

For years engineers have concentrated energies on the steam-engine of the reciprocating type. The master-minds have made important improvements in the design, and many have given up their entire existence to the science of analyzing the effects of each variation in conditions of working the steam.

Our textbooks, our teaching, our observation, all concentrated our attention on this type.

For some reason Gustav deLaval, followed by C. A. Parsons and Nikola Tesla, broke away from this spell, and we have the steam turbine engine. These individuals are endowed with master-minds, but the task of producing the turbines was probably no greater than the

task of others in improving the reciprocating type.

In one case a great step has been taken. In the other, we have an example of men of undoubted ability laboring hard for entire lifetimes with relatively small gain.

This example applies to more than the inventors' world. It has many parallels in the cold business management of a manufactory or one of its departments. Business management requires the same kind of reasoning and getting away from the spell of environment. But this phase we shall consider later under another head.

The point to be brought out here is the effect of the spell of environment in magnifying the importance of existing views and methods, and the deceptive part this trusty brain plays in binding us to unnecessarily hard work.

SEEING ONE THING AT A TIME

The tendency of the mind to see only one thing at a time is at once most valuable and most menacing. It is valuable because it enables us to forget all but one subject when we wish to concentrate our energies. It is most

menacing when this concentration is continued too long, to the neglect of other subjects.

One example of the unreliability of the normal mind is its proneness to accept as true almost any statement that is repeatedly uttered. Advertisers know this. We rebel when they overwork the method, but nevertheless the main fact is true; we are swayed by reiterated statements.

This peculiarity of the mind to be influenced by repeatedly uttered thoughts is only an example of the many ways in which our environment affects our views.

Our political and social views usually conform to those of our family or section of the country and world. We generally accept as good and right almost any long-existing condition of affairs.

Of course, we may dissent more or less, but the normal man does not get very far away from the effects of his environment.

Another characteristic of the mind is its inclination to concentrate on some apparently self-selected subject of the most trivial nature. This concentration may not be consciously entered into; it may not appear to be intense,

but it partially or wholly inhibits the view of other subjects. It usually magnifies the subject in mind and makes all others appear very small or of little consequence.

All this may seem very trivial and of little significance to the man in the works or office, but it is not trivial. If the principle is understood and used it will reduce the effort required for a given result.

All will assent to the importance of the subject. Some may agree with the statements, but it must be borne in mind that no good results will come from simply agreeing. In fact, there seems to be good reason for believing that the mere mental acceptance of a truth does not constitute useful knowledge. The mental acceptance undoubtedly precedes the full, useful assimilation of the facts, but it does not produce a change in the actions until it is fully assimilated. The unsuccessful may appear to *know* as much or more than the successful — the difference is, their knowledge is not the genuine article. They may say they know this or that truth, but their actions prove they do not believe what they say they know.

In the succeeding pages an effort will be made to indicate some of the important points to be considered. There will be no attempt to tell anything new. The main object is to urge *action* along lines that are *known* to all to be the best.

THE SPELL OF ENVIRONMENT

We can get a bird's-eye view of our field by imagining a viewpoint of an entire stranger.

If we, as a stranger, should enter any of our representative industrial plants, we should do so with a profoundly respectful mental attitude. We would undoubtedly show a full appreciation of the fact that the workshop has been a means for betterment of all the conditions of life. We would know that the printing-presses, the machinery for agriculture, our looms, and, in fact, everything that is a machine, or the product of a machine, is the direct produce of the workshop; without which there would be no printing, no machine-made cloth, no machine-formed wood, no mechanical means for transportation; in fact, none of the material things that have made the last century a record breaker.

With such knowledge, our respectful, yea, worshipful attitude would seem most fitting.

It is not for us to say one word to detract from the credit due to these makers of machinery. Even in seeing the results of their labor accredited to others, we know that it is so well marked with the real builder's name that they can continue their work of making history, apparently disregarding the fact that the world's laurels go to others.

Our profound admiration for these workers would not be lessened by our knowledge that they deal with ideals only when they are practical; that "heaven-born inventors" have no chance for success if lacking in earthly knowledge; that the engineer deals in material things, and must make things "go."

The engineer may have his ideals, but they must stand the test of reduction to practice. In the works the material and practical tests are applied to every ideal. No beautiful theory can live without some other characteristic than beauty.

As a stranger we might be interested to know the prime motive which established the business. By inquiry we might find several rea-

sons: Man's natural industry — his desire to make a machine of some kind, or to build up a large business for the glory of it, or from some altruistic motives. It is even possible, yea, probable, that we would discover the ruling incentive to be the desire for the so-called worldly gain. But whatever might have been the motive, we would know that it could not succeed without correct economic management.

The bird's-eye view then would reveal the importance of the economic side; that in order to carry out any plan based on any of the various incentives, the problem of profit and loss must not take second place.

It would seem childish to make such commonplace statements if the facts before us were not so full of proof that many of the officers, foremen, and workmen, as well as owners, sometimes forget this important fact.

It is neither necessary nor desirable that every one should take an active part in the general management of the business. But since various workmen, foremen, and officers are the real authorities who decide the character of the equipment of a plant and the general methods of work, it is necessary, from the profit-

and-loss side of the question, that all should know something more about this question than is generally known.

FINANCIAL HAZARD

The money invested in a business is secure if the management is active on the best lines for the time. But the best plan of management cannot be obtained from history.

The vast store of data of correct practice of former times will not serve the purpose. A record of the practice of even the last decade is inadequate, for rules of the game are continually changing.

The investment in an industrial plant and business is not wholly protected by fire-proof buildings and ultra-conservative management. The security must be protected by conducting the business on profitable lines.

Safeguarding the money tied up in machinery equipment and buildings is important, but should not lessen the consideration of elements which have to do with the expense of operating.

A plant and business is useless when not in motion, and when under headway requires money. Money must be poured into it steadily

to an amount which, every year, generally equals the total capital in the business.

Much time and energy have been consumed in careful consideration of the cost of the plant, but not enough thought has been given to the money tied up in the business in other ways.

CONDITIONS THAT AFFECT THE HAZARD

The hazard of investment is enhanced because the investors are inclined to be over-sanguine in starting in or in considering any new move.

Frequently the investors do not understand the practical side. The practical men do not understand the financial, and even when financial and practical men combine, the combination of their knowledge is not perfect. There are many important elements omitted.

There is always a feeling that *now* we have arrived at a time when it will pay well to go deeply into greatest refinement in shading the last mill of the last cent on labor cost of this or that piece, by the introduction of some marvelous line of machine tools. This is a case where Hope triumphs over Experience;

for surely the world is not yet finished. There are a few changes that must yet be made.

All the machines have not yet reached the last stage of perfection!

If we stake our faith on this or that as a "sure thing," we may discover some fine morning that our "sure thing" is a back number.

Of course, we know that under some conditions we can continue to make and sell a thing that is a back number many years, providing we keep up our organized work for new business. But this period should be used in getting ready for a change; it should not be frittered away in attempting to retain the old. Much time is required to get out a new product or to modify the old.

Perhaps it is the beneficent law of nature that people are slow to reject back numbers. Surely it has saved many a wreck in the past among builders of machinery, although it has undoubtedly been rather disastrous for the users of the back numbers, and equally beneficial to any of their competitors who may have been nonusers of said back numbers.

Dangers also lurk in pessimism, whether it

relates to the character of product or permanency of the market.

When we are oversanguine we are inclined to forget what we have been taught by experience.

Experience has taught us that the only perfect machine is the one we do not fully know.

The "perfect" machine may be the one that is to be tried next week, or one that has been running a few weeks or months or years. The optimist thinks it is his own machine, and the pessimist that it is the machine built by his competitors.

The kind of forgetfulness that produces the optimist is preferable to that which produces the pessimist, but neither produces the true view.

If in the past we have found it desirable to make changes in product or in our method of manufacture, it is probable that we will have a reason for doing so again.

The "perfect" machine will be found wanting in some respects, and alterations will be necessary; therefore, the business will be more secure if all moves are made with this fact in mind.

VALUE OF SPECIALIZATION

We find two extreme types of men in the optimist and pessimist. Either one is better than the man who vacillates between these extremes.

Overconfidence in one's own product is not wholly bad, and, if it induces an adherence to that one thing to the exclusion of other schemes, it may bring good results even if the scheme is more or less faulty. A faultily designed machine, well made, may be better than a poorly made machine of good design. It takes practice to produce good work, and the sticking to it gives the practice.

In the pessimist we have one who is ever ready to lose faith as soon as he discovers faults.

The wavering faith in any one machine generally results in the addition of one after another and the retention of all. This proceeding dissipates the attention, and no one machine receives the development that comes from undivided attention.

But whether the lack of constancy tends toward a variety of types or an unnecessary

increase in number of sizes of a given machine, it is invariably excused by the assertion that there is not enough business in a lesser number. This statement is frequently made, when it is common knowledge that there are from six to fifty makers who are making the same range.

This tendency to increase the number of machines manufactured is sometimes due to the readiness with which the average man accepts a new machine as better than the old. He knows the faults of the old, and he does not know all the faults of the new.

Money invested in a machinery building plant is not very safe if there is a tendency to squander the energies over too many problems.

The manufacture of a great variety of machines in response to a demand by the selling organization is a relic of other days. Our notions about methods for selling must be changed over to fit the modern scheme. And they must be *kept* up to date.

There are some very successful large companies which turn out a large variety of prod-

uct, but even the large companies are trying to reduce their line of machinery, and to "specialize." Their success will depend on whether they lead or follow in efficient specialization.

The survival of the fittest will eliminate all, excepting specialists or groups of specialists.

The largest plants may continue, by concentrating a battery of specialists on both the business and mechanical side of each subject, but this must be carried to the necessary degree of subdivision. This depends on the competition, for the combined force on one given machine must be the largest in order to be the most efficient.

The great variety or full line of machines seems to be a necessity from the mercantile point of view, but it is a woeful handicap to progress and profit to the manufacturing plant. The market conditions must be met, but it is best to know the disastrous effect of making just one more size or another line.

The entire cost of conducting a machine-building business can usually be lowered by simply continuing along with the same men. This applies to the entire organization, from the workmen to the salesmen.

Careful changes should be made from time to time, to keep up a wholesome spirit of progress.

Men should be advanced from position to position as the opportunities afford and their endowments allow. Others unfortunately must be dropped from the organization; but both the advancements and the weeding out must be carefully considered.

AMBITION MANIA

Advancements cannot be made to meet the requirements of this age of overstimulated ambition. We preach that every boy born in this country may stand an equal chance for every position from the Presidency down. Young men are told to study and qualify for great things. This is good kind of preaching — it is the kind that should be heeded, — but in some instances it is taken into the mind as meaning that every one is endowed with the ability to fill this or that great position. Then the ambition becomes the predominating idea, and the work of preparation is secondary. Then the individual fails to measure up his own qualifications. Then he becomes

obsessed with an idea of his fitness for things greater than nature ever intended. Thus he gets beyond a condition of usefulness to an organization, and must be dropped out with the disgruntled. It is one of the tragedies of life that we should try to prevent, but should never disregard.

Ambition should exist, but it should not be the sole qualification for promotion.

The management's chief business should be to take men as they are found on earth; mold them as much as possible, and place each one where he will accomplish the best results for both the organization and the individual.

Barring the disgruntled, the uncongenial, and the habitually inattentive, almost all men may be and should be profitably employed, the prime requisite being reasonably close attention to business. The thoughts must not habitually wander away from the work.

Intrigue disappears when the management quits looking for it, and assures everybody, by the general method of conducting the business, that there will be no chance to oust this or

that man. That each man will be retained in his place if he will but give reasonable application to the general interest of the organization and the particular work of his office.

The management does not "manage" if it perpetually changes its men. It should bolster up the man who lacks self-confidence; it should puncture false ambitions, and it should use men as they are found in the organization. It should not be inclined to "go back on" a man who has blundered or who has been found lacking in understanding.

It should not be over-ready to embrace a stranger just because his faults are not known.

The financial hazard of a business enterprise is greatly minimized by using men as they are found, and properly placing them at work or in offices for which they are qualified.

LACK OF CONFIDENCE IN PRODUCT

What has been said regarding the optimist, the pessimist, and the vacillating man, from the designing and manufacturing point of view of a machine business, applies with equal force to the business organization.

The business is pushed forward by men who

have confidence in the project and in the product. If these men lose their faith in their own business, they not only lose their usefulness as pushers and managers, but they become drags on the industry, and remain so until restored to normality. The hazard of investment is greatly increased by such conditions.

Instances without number have been observed in which men who have been successful have become unsuccessful through loss of confidence due to acquiring the "dangerous half-knowledge."

The man who has acquired the dangerous half-knowledge should take a postgraduate course in some institution where men are treated by all the most powerful agencies known to science. There may be no institutions of this kind in existence, but the great need will doubtless bring the establishment of many.

The men who have lost faith in their own machinery should be told that no company can survive the effects of weak-kneed advocates. Any company is better for a certain amount of aggressive competition. Any com-

pany can stand more or less opposition from its friends the enemy, but no company can continue to exist under the blighting effects of the men who have lost this confidence in them or their product.

The postgraduate course for restoration of the near-wise man should include educational means of all kinds. The means should be especially adapted to the need of each student or patient.

There might be a phonograph in each room, which should work all night and all day. This machine should repeat over and over a few short sentences like the following:

"The only perfect machine is the one you do not know."

"Study the machines offered by your competitors, just to get the same degree of knowledge of the 'other' machines — not for the purpose of slandering or even mentioning — but just to restore your confidence in the relative value of your own machine."

"Don't try to get back your belief that your own machine is perfect — that has gone forever — only look at the other machines and learn that your own is the best."

This kind of confidence will not be exuberant, but it will have marked efficiency in the cold gray world in which you are to again try your strength.

CONFIDENCE IN EXISTING THINGS

The new confidence acquired by this treatment is born of a knowledge of the *superiority of existing things* — things that may not be perfect but are nevertheless best.

This treatment will forcibly impress on the mind that every machine requires a complete organization, which combines and includes the inventor, the business managers, the manufacturing officers, and last, but not least, the men who do things, the workers in every department. And this extends to every detail of the work necessary for the construction, shipment, and operation of the product.

The inventor may have had almost complete knowledge regarding the best way to make each part, just how each fit should be made, and just how the machine should be operated under each combination of conditions. But it is far more probable that the inventor never had all this wonderful knowledge.

If he knew all this, it would be of value providing he had some perfect way of imparting his knowledge to each individual worker. We know, however, that this is impossible, even with the most thoroughly organized companies.

It takes years to get each piece made as it should be made, even with no change of design, and this is not accomplished by any other process than continuous practice, which is only acquired by actually making these pieces. The quality and speed of production increases with this experience, and are not acquired without it.

The art of assembling and operation of the machine is developed in the same way. There are other means that facilitate, but nothing that takes the place of practice.

The knowledge of the machine must not be only in the inventor's head. It is not even enough to have it thoroughly known by all the officers, including foremen. It must be patiently transmitted to the real workers.

A wonderful invention is only of material value when it has been in active use long enough for many men to have acquired knowledge

regarding it and skill in production of its various parts, assembling and operating.

It may have a prospective value, and that may be something salable, but the point to be made clear is, that real material value of an invention is not realized till it is used. To have it used requires more than the inventor's vision, and more than the drawings and specifications. The invention must be given form and use.

A machine is a combination of the original idea with many subsequent ideas which have been added to it by continuous application. These subsequent ideas are supplied by the men who do things, who make and use the machine. These ideas do not show in the general design, but they are there* in fact. They represent ideas as to proper fit of this or that part, of the advantage of easing this or that bearing at this or that place. They represent the accumulation of the ideas regarding proper tension for each adjustment, and thousands of other points that may or may not have been anticipated by the inventor, points that probably could never have been known by any other process than that worked out by

actual thought combined with experience in the construction and use of the invention.

THE WORKERS HELP BRING SUCCESS

The inventor, the officers, and mayhap the foreman, taken all together, do not and cannot make a successful machine or business without this supplemental work or ideas that come from actual work of all workers.

This new kind of knowledge should not take away a man's courage; on the contrary, it should give him a true sense of value of existing, "going" things. With this knowledge he can confidently and earnestly push a machine that is the product of a good organization. He will know the great value of much experience and practise of each of the many men in the organization. He will neither kill the business by half-hearted indorsement, nor increase the hazard of investment by urging this or that modification. Nor will he advocate this or that machine being added to a line that is already too great.

The invention, the general organization, the proper direction of the business, are essential to success. But without that organization

which is only obtained by actual, thoughtful experience of the men who do things, all the knowledge and industry of the leaders are utterly useless.

This knowledge produces a new kind of confidence that has greater faith in the existing and running things than in the claims for something that has not had the development of practice. It is the confidence that knows that the right fundamental ideas and the policy of "sticking to one thing" will accomplish the best results.

This is not a doctrine of optimism that holds there is no inferior machine. The "best" implies the existence of the inferior. In nearly all lines there are many grades from the best to the worst, but the loss of faith in the relative value of a machine is most commonly due to a lack of full knowledge of the other types, and it is this kind of loss of courage, confidence, or whatever it may be, that this chapter is intended to offset.

PROGRESS WITH FULL KNOWLEDGE OF FACTS

New schemes or new inventions may be full of promise, but cannot be realized without the

various elements which include the man and his persistent industry in organizing as well as inventing — in manufacturing and selling as well as promoting.

Belief in the superiority of existing things is not a barrier to real progress. It is not a submission to the spell of environment. It is simply an appreciation of an important fact. Progress should be made subject to this foreknowledge.

The spell of environment that should be exorcised away is not the spirit of progress — it is the group of fundamentally erroneous ideas regarding values of various methods of manufacture, general conduct of business, and principles of machine design.

Here are a few of the errors:

“Anything new must be good.”

“Tinker & Change Machine Tool Company are bringing out a new model. It’s a wonder worker.” [Said company seldom make two lots alike.]

“Experience in manufacture and use of a new machine is of value, but not essential to its success.”

“The talk of profit of a business should be in whispers. It is against the welfare of the workers.” [As if good wages or salaries could be paid by an unprofitable enterprise.]

“The idea that specialization of the processes for producing machines is harmful to the machinist trade because it tends to simplify and make less difficult the production of certain kinds of work.” [As if it were to the advantage of the machinist to be forced to work with poor implements, when in other plants, cities, and countries good tools are being furnished to each man — tools which enable each man to do the best work of which he is capable in the most favorable circumstances — methods of specialization which take the ordinary work away from the extra good workman and supply him with high-class work only, making his return the greatest, and making it possible to pay him good wages. As if it were possible to pay good wages when good men are required to do medium work, and all men on account of inferior tools are handicapped in their production. As if these questions of profit were not of vital interest to every worker and officer, as well as owners.]

The group of persisting erroneous ideas regarding machine design is so large and so strong that a summary would fail to serve any good purpose. Therefore, no attempt will be made here to even outline these ideas. It is hoped that each reader will make an effort to get back to nature in surveying the field.

LARGEST PROFIT PER DOLLAR INVESTED

One of the most satisfactory policies of management is that which tends toward getting the best return or profit per dollar of investment.

We shall not refer to the quality of the product, the design, or any other elements which affect the good name and standing of the business, for it goes without saying that no business can be maintained where these are disregarded. The point to be brought out here is that, these things being equal, the best scheme of management for profit is one that puts the capital where it will do the most good.

The above statement is one with which all will agree, but strangely enough there has been a tendency to tie up capital in ways that actually throttle the output of the entire business.

Furthermore, this is frequently done by increasing the portion of the investment that is irrevocably tied to the existing product, thus not only reducing the earning power of each dollar invested, but also increasing the hazard by tying the capital to the present product, which soon may be unsuited to the market demand.

One of the most common errors in this respect is the one that regards the reduction of the labor cost as the paramount consideration.

Reduction in labor cost has been the war-cry. The pay-roll has been talked about so much that it has seemed to become the whole thing. A man who declares that the labor cost per piece is not the most important element is at once branded as an advocate of old-fashioned methods.

It is needless to give assurance that there is no intention to disregard the labor cost. The net cost per piece is a very important element, but it should neither eclipse the question of profit per dollar invested, nor the risk of the capital tied up.

What is the gain if the means for reduction

of the net labor cost reduces the profit more than the saving in labor? If doing so results in an actual loss of profit, why is it done?

We can readily see that the overhopeful managers may disregard the risk of the money invested, but we cannot see why the relative importance, or rather unimportance, of the labor cost should be so disregarded.

The machine tools in a plant usually determine its character. This character is not one that can be quickly changed, but every addition to the equipment does change it for better or worse. Usually the installation of a new machine is hailed as a progressive move, just because the new machine works better than the old, but its effect may be very bad. It may be changing the character of the plant adversely to the interests of all concerned. Therefore, the controlling spirit should see to it that each move is made on a basis that is economically sound.

It is in these changes that the scheme of management has a chance to make a great difference in the earning power of the entire business.

If too large a proportion of the total avail-

able capital is tied up in the machine equipment, the business is handicapped. There is a right amount which bears a certain relation to the total required to carry on the enterprise.

With a given amount of capital for machine equipment, the output of the plant will be seriously throttled if the net cost of labor per piece machined is allowed to become the controlling element.

COST OF THE PRODUCT

The practice of disregarding the profit, when considering changes in machine equipment, is the natural outgrowth of the separation of the mechanical and the business departments.

The changes in the equipment are usually determined by the mechanical department, and this is done with particular regard for the quality of work and the cost per piece. The relation between the profit and the net labor cost is not considered.

The cost of the product of the average machinery-building plant may be divided into three nearly equal parts: the material, the labor, and the burden; or, in four equal

parts, if a reasonable interest charge is made for the use of the capital invested.

The material is the iron, steel, and other material that enters into the construction of the machine, and it is taken in the condition in which it usually comes to the machine shop.

The burden includes all expenses and salaries necessary for the maintenance of the business.

About one-half the amount paid for labor goes to the men who run the machine tools, and the other half is paid to workmen who do the other work, such as handwork, assembling, transporting, etc. Therefore, the cost of machining is either one-sixth or one-eighth of the total cost.

On top of the net cost of the product there should be a profit. If it is not there, the sooner something happens the better. If it is there, then it is proportioned to the volume of the output. Therefore, both the size of the output and the labor cost should be kept in mind.

The size of the profit per unit of output is not generally known to the mechanical departments. But even if it is not known, there is no reason for their being uninformed as to the

importance of large output for cost of the plant.

TYING UP CAPITAL IN STOCK IN PROCESS OF CONSTRUCTION

The amount of capital tied up in raw material, supplies, stock in process, and finished product should not be greater than that which is necessary to get the greatest output per dollar of investment.

In the machinery-building world there is no such thing as a steady, long-lived demand for any machine. Hence the proposition to build a locomotive or an automobile or printing-press by methods employed in watch or sewing-machine manufacture is entirely ill-timed at least.

For this reason the stock in process must not necessarily be considered insufficient if it appears to be on the hand-to-mouth plan. The dividing line between excessive and insufficient stock must be drawn in each individual case.

Raw material should be purchased in reasonable quantities, with due regard to the price which varies with quantities, but there should always be a regard for the amount of capital

used for this purpose. Any excess represents just that much extra capital unnecessarily risked in the business.

There should be a constant supply of material throughout the entire work. The stock in process should flow through the plant in a rapid but thin stream. The quantity should be no greater than absolutely necessary to insure a steady supply for all of the workers, including the assembling and selling workers.

An excessive stock of this or that piece, or of all pieces, means that much capital idle, and it also tends to slackness of management. Frequently it is the outcome of carelessness.

A plant will run almost without management if given latitude in the amount of stock carried in raw material, in work in process, and in finished product. No great care need be taken in purchase of material or in putting in the shop orders. All that is needed is to just hurry forward the stock that "happens" to be "out," and at the same time allow the accumulation of the unneeded stock to go on unchecked.

And it is no uncommon sight to see this all going on under the same management.

Immense storerooms for keeping finished stock are shown with pride, unmindful of the fact that every dollar's worth of unnecessary stock on the shelves in the stock-room, every dollar's worth of unnecessary work in the plant, represents idle money and faulty management.

If this money is to be retained in the business, the system should be changed so that the money will be put where it will bring the best return.

The excessive stock in process is sometimes an outcome of blind progressiveness—the blindness that fails to see that there is as much money tied up in stock in process and in finished product as there is in the entire machinery equipment.

An adaptable equipment facilitates keeping down the amount tied up in stock in process. The modern plant should take advantage of these modern methods and machines which tend toward profitable use of capital. Such machines are highly developed and true to the controlling ideal of adaptability and largest output per dollar of investment.

